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DRAINAGE CORRELATION RESEARCH PROJECT

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FINAL REPORT

DRAINAGE CORRELATION RESEARCH PROJECT

For the

Montana State Highway Commission
Planning Survey Section

In cooperation with the
U. S. Department of Transportation
Federal Highway Administration

By

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The opinions, findings and conclusions expressed in this publication are those of the author and not necessarily those of the Federal Highway Administration and the Montana State Highway Commission.

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TABLE OF CONTENTS

VOLUME II

APPENDIX A. Review of Hydrology Concepts

APPENDIX B. 1. Map of Montana Showing Instrumented Watersheds

2. Maps of Instrumented Watersheds

3. Aerial Photographs of Instrumented Watersheds

APPENDIX C. Watershed Characteristics

APPENDIX D. Soil Characteristics

APPENDIX E. Hydrologic Data

APPENDIX F. Variables for Multivariate Statistical Studies

APPENDIX G. Comparison of Stochastic Peak Flow Methods

APPENDIX H. Tests of Annual Peak Discharge Data to Determine Hydrologically Homogenous Areas

APPENDIX J. Effect of Record Length of Peak Flow Predictions

APPENDIX A

REVIEW OF HYDROLOGY CONCEPTS

PARAMETRIC METHODS A-3

- Correlation Analysis A-5
- Combined System Analysis and Synthesis A-8
- General System Synthesis A-13
- General System Analysis A-16

STOCHASTIC METHODS A-18

- Mass Diagrams A-18
- Statistical Methods for Estimating Frequencies A-19
- Hydrologic Simulation A-36

SUMMARY A-40

REVIEW OF HYDROLOGY CONCEPTS

The science of hydrology has undergone enormous changes in the last few years. Many techniques now considered common-place had scarcely been conceived of ten years ago. Even the teminology has changed radically in the past decade. Hydrologists now talk conversationally of deterministic, parametric, or stochastic hydrology, of Markov chains, and Monte Carlo methods. When this research project was undertaken in 1963 it would have been difficult to even find reference to such terms in the most advanced hydrologic literature. In this section an overlook at modern prediction hydrology will be presented with an attempt to show how the effects of this project relate to present-day hydrologic practices.

The American Society of Civil Engineers Committee on Surface Water Hydrology (1963) described "parametric hydrology" as the development of relationships among physical parameters involved in hdyrologic events and the use of these relationships to generate, or synthesize, non-recorded hydrologic sequences. The same ASCE committee described "stochastic hydrology" as the use of statistical characteristics of hydrologic variables to solve hydrologic problems. As related to peak discharge investigations, parametric hdyrology methods all solve attempts to somehow describe a "system mathematically. The system may include characteristics of a watershed, meteorological phenomena of a storm, etc. The system is often pictured as a "black box" into which ideally one feeds a rainfall event (for example), turns the crank and pulls out a flood hydrograph. Stochastic hydrology methods is peak discharge studies are those which pay no attention to precipitation, watershed characteristics, but rather consider only the statistical nature of recorded runoff events.

In addition to prediction methods which are based upon purely parametric hydrology or purely stochastic hydology, there are a number of techniques which incorporate some features of each. An example would be a procedure in which a number of gaged watersheds are studied by stochastic hydrology, and the results of this study extrapolated to nearby ungaged watersheds on the basis of a regression equation relating watershed parameters.

A comment regarding "deterministic hydrology" might be useful at this point. Deterministic hydrology implies that a unique cause-effect relationship exists, with no element of chance involved. For a rainfall-runoff event that occurred last year, for example, it would be theoretically possible to write a singular mathematical function relating the streamflow to the causative precipitation, infiltration, evaporation, etc. Hence, this is an example of deterministic hydrology. (The fact that the mathematical function may never be written because of lack of data does not alter the idea that the solution is nevertheless deterministic). With regard to a rainfall-runoff event that will occur next year, it would be impossible to define an unique hydrograph, perfect in every detail, for a given rainstorm (even if it were possible to know in advance the precise characteristics of the rainstorm). Any aspect of prediction hydrology, therefore, is stochastic, because there is always at least some element of probability, chance, or statistical variation attached.

All methods of peak discharge investigation, whether parametric, stochastic, or mixed, share two inherent limitations, which are not always expressed, but which are always implied. All depend upon historical records of the values of some measured parameters, and all depend upon the assumption of time invariance or "stationarity" of the hydrologic systems. The first limitation implies that errors in the basic measured data will cause errors (perhaps larger) in the predictions; the second limitation implies that if long-term, natural or artificial, cyclic changes or trends (the earth is warming up, for instance) exist, errors will be introduced into the studies, and no prediction of the magnitude of these errors can be made.

PARAMETRIC METHODS

Several differnt Parametric Methods have been proposed and these will be described herein. Included are Correlation Analysis, Combination System Synthesis and Analysis, General System Synthesis, and General System Analysis.

Although these methods have certain basic differences, they all conceive of the rainfall-runoff phenomena as a three-phase problem. As shown in Figure A-1, input (precipitation), is acted upon by a system, to produce an output (runoff).

Given two of the three phases shown, the third can be obtained (at least a solution, but not necessarily an unique solution). Amorocho and Hart pointed out (1964) that in the usual investigation, recorded historical input and output data are used (with or without watershed parameters), to construct a mathematical model of a system which (hopefully)

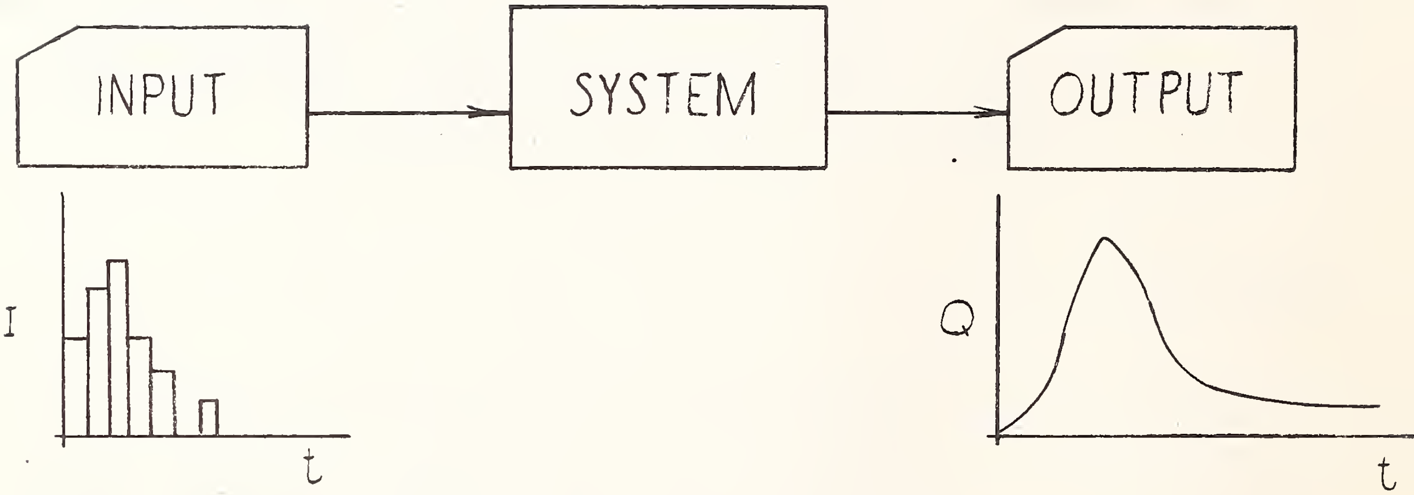


FIGURE A-1. The generalized "system."

accurately, describes the real-world system. This mathematical model is then used in conjunction with hypothesized (synthetic) input or output to generate predicted values for the unknown phase. Operation of the model after it has been constructed (which of course is the purpose or motive for the investigation in the first place) is abbreviated by Amorocho and Hart as ROP (for reconstruction of past sequences or prediction of future behavior).

It should be pointed out that parametric methods do not yield flood magnitudes in terms of recurrence frequency. Rather, they are used to relate an input (rainfall event) to its resulting output (runoff hydrograph). Stochastic procedures must be incorporated into the investigation if recurrence frequencies are required.

Correlation Analysis

In this procedure various combinations of variables are tested to explore the significance of their effects in the hydrologic system. For a given combination of variables a regression analysis is performed to determine the best-fit equation relating them. Each such equation (or model) yields a set of error estimates and measures of correlation, as determined by analysis of variance. The combination of variables which yields a relationship most closely approximating the recorded output function in terms of the recorded input function (as determined by the error estimates and measures of correlation) is deemed to be the best combination, and its regression equation is adopted as the prediction equation.

The often-used and much-abused "rational formula"

$$Q = C\, i\, A \tag{A-1}$$

might be visualized as a correlation equation although it is doubtful whether it was originally formulated as the result of regression analysis. It relates peak discharge Q to an input term i (a statistical value of average rainfall intensity over a time period corresponding to the estimated time of concentration of the drainage area) and a watershed parameter A (watershed area). The runoff coefficient C could be thought of as a regression coefficient or retardance coefficient which has been determined empirically for various ground cover conditions. Many equations more sophisticated than the rational formula have been proposed, involving linear or nonlinear relationships among few or many variables.

Correlation analysis methods are basically empirical. Their principal disadvantages are that almost equally good prediction equations often result from entirely different sets of parameters, and the investigator's judgment as to the physically relevant parameters largely controls the success of the operation. Also, use of parameters which are interdependent may lead to erroneous results. Sharp, et al. (1960) reported on multiple regression studies of two watersheds, one in Kansas and one in Oklahoma. They used various combinations of up to eight independent parameters and one dependent parameter (discharge peak). They found that the quality of the predicting equations became progressively poorer for values far removed from the average. Although they had high correlation coefficients this seemed to indicate only that reasonably good individual estimates could be made near the means, but as estimates were made for values farther and farther removed from the means, probable errors increased enormously. In many cases they found inverse correlations with some of the variables when physical considerations plainly seemed to require direct correlations, and vice versa. They concluded that their indifferent success could be traced to four assumptions inherent in application of the methods:

1. There are errors only in the dependent variable (discharge peak). No errors occur in the independent variables.
2. The variance of the dependent variable does not depend on the values of the independent variables.
3. The observed values of runoff are uncorrelated random variables.
4. The population of the dependent variable is normally distributed about the regression line for any fixed level of the independent variables (precipitation, for instance).

Sharp, et. al., felt that with hydrologic data all these assumptions are suspect and that the fourth assumption in particular is usually violated because the discharge peaks are badly skewed about the regression line and do not approach a normal distribution. For these reasons, and because there seems to be no reliable, nonsubjective way to eliminate personal factors associated with the selection of relevant parameters to begin with, they concluded that very little reliance could be placed on the final equations.

Combined System Analysis and Synthesis

To understand this method and those that follow, it is first necessary to define and discuss the terms "system analysis" and "system synthesis." In system analysis a mathematical process involving the use of measured input and output only (without any attempt to describe explicitly the internal mechanisms of the system) is used to establish the relationship between input and output. This relationship takes the form of a unique function which is made to operate on the input to produce the output. The function does not have to have a physical meaning or possess parameters fulfilling conditions of dimensional consistency. The analysis may be either linear or nonlinear depending upon the form of the function selected to establish the input-output relationship.

In system synthesis the operation of the system is described by a linkage or combination of components whose presence is presumed to exist in the system and whose functions are known and predictable. The linkage of components is made in such a manner that whenever a specified input is applied the correct output is produced; but the process of synthesis usually does not yield an unique model of the system.

Pure analysis or pure synthesis can be performed on a system independently, but frequently a combination of both is employed. The classical unit hydrograph procedure is an example of a combination of analysis and synthesis.

Unit Hydrograph

The unit hydrograph procedure is a three-phase operation as has been described and diagrammed earlier (page A-3). In this case the gross input in first modified by infiltration over the surface of the watershed to yield a "rainfall excess" function. The surface elements of the watershed then operate in the rainfall excess function to generate a surface runoff function, which is modified in turn by the base flow to produce a flood hydrograph. The first and third phases of the procedure could be classed as system synthesis, while the second (inversion of rainfall excess into surface runoff by means of a unit hydrograph) is an example of system analysis.

The first phase, modification of gross input into rainfall excess function, is accomplished by one of several techniques each of which is empirical, subjective, and inexact. Infiltration tests might be run on different soils on the watershed to determine infiltration capacities (maximum rates at which infiltration can occur); soil moisture conditions prior to the storm might be estimated (by actual soil moisture measurements if possible, or by use of an 'antecedent precipitation index'); or judgment might be used to determine that some fraction of gross rainfall should be expected to infiltrate into the soil or otherwise be lost through surface detention, interception, etc. The resulting rainfall excess function is certainly not determined uniquely, but it does result from attempts to describe the operation of this part of the system by means of components which are undeniably present.

The third phase, that of modifying the surface runoff function into flood hydrograph, is again an inexact procedure. There is no doubt as to the existence of base flow, nor the fact that it modifies storm runoff. But subjective techniques must be employed to make the actual transformation and the resulting solution is not unique.

The second phase, which of course is the heart of the procedure, employs the unit hydrograph concept advanced by Sherman (1932). Sherman defined the unit hydrograph as that hydrograph resulting from one inch of rainfall excess from a storm of specified duration. Since losses and accretions are accounted for in phases 1 and 3, the unit hydrograph represents exactly the same volume of water as did the rainfall excess hyetograph, namely one inch of water from the entire watershed area. It therefore represents a direct inversion of water from rainfall to streamflow.

A unit hydrograph is developed for a watershed by analysis of a suitable storm hydrograph, after first subtracting out the base flow. Knowing the volume of runoff in the surface runoff hydrograph, each ordinate is scaled upward or downward a proportionate amount to produce a hydrograph having the required one inch of volume. This is said to be the unit hydrograph for storms of similar duration. After it has once been developed, the unit hydrograph may be used for ROP purposes and is strictly a linear analysis tool. (A storm with two inches of rainfall excess will result in a surface runoff hydrograph with a peak discharge exactly double that from a storm with one inch of rainfall excess). It gives unique results which are not dependent on watershed factors, etc.

In practice several storm hydrographs (from storms of similar duration) may be analyzed to produce an average unit hydrograph, and of course many unit hydrographs are needed, one for each storm duration. (Linsley, Kohler, and Paulhus, however, suggested (1958) a method whereby available unit graphs for a watershed might be utilized in producting a unit graph for some other storm duration).

On small watersheds, and in arid regions generally, data are not often available from which to construct unit hydrographs. Snyder (1938) proposed a "synthetic unit hydrograph" method for use in such situations. He defined the unit hydrograph peak in terms of drainage area and time lag (the time interval between centroid of rainfall excess and the hydrograph peak). Another empirical relation is used to define the shape of the hydrograph; and the unit hydrograph thus synthesized may be used in the same fashion as ordinary unit hydrographs. Unit hydrograph synthesis can only be applied to watersheds where major floods result from single storms over the entire basin, and this restriction limits the procedure to use on very small basins only. Hickock, et.al., (1959) suggested that in the Southwest synthetic hydrographs could not be used on watersheds larger than 1000 acres. Renard and Keppel (1966) reported that they had divided larger watersheds into subareas, developed synthetic unit hydrographs for each, and had used routing techniques to obtain final hydrographs at watershed mouth. These methods are extremely time consuming and laborious. The U. S. Soil Conservation Service uses essentially the same procedure for ungaged watersheds, but utilizes digital computer programs to expedite solution. The SCS technique was described in detail by Ferris and Williams (1968) and has been discussed earlier in this report (Chapter VI).

The unit hydrograph procedure has been widely acclaimed as a valuable tool in flood predicting. Recently, however, there have been several disturbing reports which imply that the procedure is less valid than had been though. Ancorocho and Hart, for instance, cite evidence indicating that this method tends to underestimate flood episodes which are larger than those used for its analysis and to overestimate small floods. They attribute this apparent defect to the fact that the watershed is basically a nonlinear system, to which is forced a linear function. They concede that there are many instances where linear approximations are valuable, and that linear analysis is much simpler and easier to use than non-linear analysis, but they caution that grossly erroneous predictions may accrue, without any foreknowledge of the magnitude or sign of the error. These authors conclude by pointing out that the unit hydrograph method treats the input and output as 'lumped' parameters, meaning that the areal distribution and variability of the input (rainfall) are not considered to have any effect on the output.

General System Synthesis

With the advent of the electronic computer has come the capability for construction of synthetic hydrologic watershed models. The much-publicized Stanford Watershed Model (Crawford & Linsley, 1966) is the best known example of this method. The Stanford Model (and others like it) rely on a statement of continuity, which can be expressed as

$$I = Q + \triangle S \tag{A-2}$$

where I is total inflow, Q is total outflow, and $\triangle S$ is change in internal storage; all referred to a time interval t_1 to t_2. This equation is differentiated to yield

$$i(t) = q(t) + (\frac{ds}{dt}) \tag{A-3}$$

where i(t) is rate of total inflow, q(t) is rate of total outflow, and ds/dt is rate of change in internal storage.

The process of general synthesis typically is begun by postulating a simulation model (usually complex) whose structure is based on an assumed knowledge of the phenomena involved in the hydrologic cycle. The Stanford Model for instance includes relationships involving precipitation, evapotranspiration, interception, infiltration, groundwater storage and movement, overland flow, interflow and channel delay (among others). Explicit mathematical functions are developed to define operations effected on various elements of the input and storage, after which the recorded input is processed through the model, usually with the aid of a digital computer (occasionally an analog computer) and the resulting output compared with recorded output of the natural system. If there is unsatisfactory agreement, various components of the model are adjusted or modified, and the process repeated until satisfactory agreement between computed output and recorded output results. At that point the model is assumed to be properly adjusted and it may then be used for ROP purposes.

Most of the synthetic models developed thus far, including the Stanford model, have proceeded from a very detailed model of a relatively small area. As computer capabilities and modelling experience have progressed, some of these models have been expanded to encompass larger and larger areas. An investigation which has been recently undertaken by the departments of Civil Engineering and Engineering Mechanics and Industrial/Management Engineering at Montana State University is aimed at development of a state-wide model for Montana. This model is based on a "systems" approach of beginning with a state boundary model, progressively subdividing into smaller and smaller units, with corresponding increases in completely defining system components in greater detail and with greater accuracy.

Both linear and nonlinear models have been produced. As was mentioned earlier, linear relationships are far easier to develop than are non-linear relationships. But ultimately the basic non-linearities in the basin must be reckoned with and recognized in the model.

Reports in the literature indicate that results from some of the watershed models are encouraging; but there are differences of opinion as to how reliable they are for reconstructing or predicting detailed runoff events, such as peak flow hydrographs. Amorocho and Hart suggest four probable causes for lack of reliability: errors in recorded data from which the model is constructed, effects of areal distributions of parameters, imperfections of the model structure, and nonuniqueness of the synthesis process.

The first two of these causes are common to other techniques as well as to that of system synthesis, but these authors fear the magnitude of errors may be much larger when using synthesis. Subdivision of the hydrologic unit into subareas, each with its own parameters, is a way of reducing the problem of areally distributed parameters. This technique is used on the Stanford model, and is being built into the Montana Water Planning model. Model structure imperfections are inevitable because of the necessity to simplify the model from the natural system. In the first place a natural system is simply too complex to describe in all its details; in the second place, the kinds and amounts of data required would become nearly impossible to collect. Since the synthesis process is not unique, it follows that any synthetic model must of necessity be non-exact. Even though a model faithfully reproduces historic records, there must always be uncertainty as to its performance when out-of-range.

General System Analysis

Most system analysis attempts, at least up until a few years ago, have been based on linear techniques. The unit hydrograph method, for example, utilizes a linear analysis (with synthesis involved at both input and output ends). As was mentioned earlier, the watershed is basically a nonlinear system, and the unit hydrograph procedure of forcing all the nonlinearity into the input and output synthesis is artificial. Linear techniques are much preferred by investigators because of their simplicity. In fact, the analysis of nonlinear systems had been barely considered prior to 1960. Within the past few years, however, considerable progress has been made in the adapting of nonlinear analysis to the study of hydrologic systems.

An advantage to the use of general system analysis is the fact that it is the fact that it permits relationships to be established between partial inputs and partial outputs without satisfying physical continuity conditions for the entire system. In theory at least it permits direct operation with recorded precipitation and recorded river runoff without considering internal parameters such as evapotranspiration and groundwater flow.

The process consists essentially of analyzing the recorded input and recorded output to find an equivalent system function or convolution. In the linear case the inversion is the unit hydrograph, or its equivalent; in the nonlinear case the inversion is an integral function.

Current procedures utilizing nonlinear analysis usually involve approximations because general methods of direct nonlinear inversion are not yet available. Amorocho and Orlob (1961) reported a nonlinear system analysis which was based on the assumption that a hydrologic system is equivalent to an analytic system of progressively higher ordered terms, whose output when added equal the output of the natural system:

$$
\begin{aligned}
y(t) = & \int_{-\infty}^{\infty} h_1 (\tau_1)\, x\,(t - \tau_1)\, d\tau_1 \\
& + \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} h_2 (\tau_1; \tau_2)\, x\,(t - \tau_1)\, x\,(t - \tau_2)\, d\tau_1\, d\tau_2 \qquad \text{(A-4)} \\
& + \iiint \dots + \dots
\end{aligned}
$$

where h_1, h_2, etc. are system functions of progressively higher order; x is input; y is output. All terms are functions of time. The task is to evaluate each of the nonlinear kernels of the functions of this series. When complex inputs are involved, approximation is necessary to evaluate the series.

In its present stage of development, nonlinear analysis has been applied only to systems which are time invariant, and to systems with lumped parameters. The method offers promise, however, of utility in distributed parameter situations with time variance.

STOCHASTIC METHODS

The parametric methods described above for determining streamflow discharges are not often satisfactory for establishing return frequency directly. Usually these methods require starting from a hypothesized rainfall event, generating a hydrograph, and finally estimating the return frequency of the causal storm.

Stochastic hydrologic methods are used to establish the level of probability with which certain streamflow magnitudes or sequences of magnitudes are likely to occur in the future. They work strictly from previously recorded streamflow data, and are in no way dependent upon watershed or storm event parameters. The stochastic problem is simply this: given a historic sequence of events, with historic data available, what inferences can be deduced from their statistical distribution to assess the probabilities of future sequences.

Mass Diagrams

Until recent years analysis of reservoir capacity requirements, possible yield, and other similar problems usually started with the assumption that the past recorded record fully describes all possible combinations of events, and that future operations can be planned by utilizing such a chronology without transformation. In spite of the weaknesses of such an assumption this procedure is still widely used for these purposes. Construction of a mass diagram, which shows cumulative flow volume as a function of time, permits graphical solution of the problems being studied.

Statistical Methods for Estimating Frequencies

The traditional approach for determining peak discharge frequencies by stochastic analysis has been to conduct a frequency analysis in the light of a pre-conceived distribution model. At least a dozen distribution models have been proposed, and one of the investigator's biggest problems is deciding which of these is the correct one to use. Although there is no conclusive evidence at present to indicate that any one model is proper for all hydrologic regions, the federal agencies dealing in water resource development have all been directed by the Hydrology Committee, Water Resources Council (1967) to use a single method, the Log-Pearson Type III. This model and others will be discussed below, following a discussion of central tendency and divergence.

Mean and Standard Deviation: Several terms are used to describe an average or central value of a series of values (say streamflow peak discharges). In hydrologic analyses, the measure customarily used is the mean, which is defined as

$$\mu = \frac{\sum X_i}{N} \qquad \text{(A-5)}$$

where μ is population mean

X_i is magnitude of an individual event

N is the number of events

Likewise, there are various ways of describing the divergence or scatter of events about the average or mean. In general no single term gives a complete description of the divergence, but the most commonly used quantity is standard deviation.

$$\sigma^2 = \frac{\sum_i (X_i - \mu)^2}{N - 1} \tag{A-6}$$

where σ is standard deviation and the other terms are as defined before.

Population versus Sample Mean and Standard Deviation: In hydrological analyses "population" mean and standard deviation can not be calculated precisely because the population of hydrologic events is infinite, and values for only a fraction of the events are recorded or "sampled." The "sample" mean and "sample" standard deviation are computed from n recorded events as

$$\overline{X} = \frac{\sum_i X_i}{n} \tag{A-7}$$

and

$$S^2 = \frac{\sum_i (X_i - \overline{X})^2}{n - 1} \tag{A-8}$$

where $\overline{X}$ and S are sample mean and sample standard deviation. It is possible, of course, that $\overline{X}$ and S will have the same numerical values as μ and σ respectively, but it is more likely that the values will not be the same. As n becomes larger, the computed values of $\overline{X}$ and S can be expected to more closely approximate μ and σ. Statistical procedures are available for estimating the likely error in $\overline{X}$ and S for given sets of data, and hence setting upper and lower probable limits for μ and σ.

Probability: The likelihood that a certain event will occur may be expressed in terms of its "probability." Probability is a fraction lying between 0 and 1; the larger the fraction, the greater is the likelihood that the event does occur. If the probability is 1, it is mathematically certain that the event will occur; if it is zero, it is just as certain that the event will not occur. Probability is defined by

$$P = \frac{\text{Number of successes}}{\text{Total number of events (equal to number of successes plus number of failures)}} \qquad \text{(A-9)}$$

If the event being described does occur, it is considered a "success"; if it does not occur, it is considered a "failure". In terms of streamflow discharge on a given river, for example, where historic records are being studied, the probability that the discharge will exceed a specified magnitude could be determined from

$$P = \frac{\text{Number of recorded streamflow events greater than specified magnitude}}{\text{Total number of recorded streamflow events that have occurred.}}$$

Normal Distribution: The equation of a normal curve was published as early as 1733 by de Moivre, and developed independently by Laplace, 1749-1827, and Gauss, 1777-1855. The normal curve was largely ignored until 1924 when Karl Pearson found a copy of de Moivre's report in a library. If a series of streamflow peaks fits a normal distribution, the graph of probability of occurrence versus magnitude of events produces a "bell-shaped" curve which is symmetrical about the mean.

A typical normal curve (sometimes referred to as Laplacian or Gaussian) is shown in Fig. A-2. The curve theoretically extends to infinity in both direction indicating there is no magnitude of Q for which the probability of occurrence is exactly zero. The area under the curve between two values of Q, say Q_1 and Q_2 represents the probability of the streamflow peak lying between those values of Q. (This is shown as the cross-hatched area on the figure). The total area under the curve is 1, since it represents all possible events.

For a normal distribution, the curve is completely defined (and hence the probability of any discharge occurring can be determined) if the mean, μ, and standard deviation, σ, are known. The standard deviation defines a discharge, measured in each direction from the mean, such that the area under the probability curve between the discharges $\mu - \sigma$ and $\mu + \sigma$ is 0.68. This means that for a normal distribution the probability is 0.68 that a given streamflow peak will lie between the values $\mu - \sigma$ and $\mu + \sigma$.

The probability of occurrence of any discharge Q can be computed from

$$Q = \mu + Z\sigma. \qquad \text{(A-10)}$$

The multiplier Z is a frequency factor which can be determined for any desired probability, from Table A-I. The tabulation simply describes the shape of the frequency distribution function for the case where $\mu = 0$ and $\mu = 1.0$.

Because of its simplicity, the normal distribution is often assumed in hydrologic studies. But if the normal distribution were correct it would require the possibility of negative discharges, as indicated in the sketch below. Sometimes the theoretical probability of negative Q values is small enough so this defect can be neglected. It is evident, however, that streamflow data never fit a normal distribution exactly.

TABLE A-I: Probability of a Random Value of $z = (X - \mu)/\sigma$ Being Greater Than the Values Tabulated in the Margins

z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641
.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
3.6	.0002	.0002	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001
3.9	.0000									

Log-Normal Distribution: Chow (1954) noted that many kinds of statistical data, including streamflow data, form a skew frequency distribution as sketched in Fig. A-3, but that their logarithms are nearly normally distributed. If the log - normal distribution applies, then the discharge corresponding to any particular probability is determined from

$$Q = \mu + K \sigma \tag{A-11}$$

As in the normal distribution, K is a frequency factor, but it now depends on the coefficient of skew or coefficient of variation as well as probability. The coefficient of variation is

$$C_v = \frac{\sigma}{\mu} \tag{A-12}$$

and coefficient of skew is

$$C_s = \frac{n}{n-1} \frac{\frac{\sum(x^3)}{n} - 3 \bar{X} \frac{\sum(x^2)}{n} + 2 (\bar{x})^3}{3} \tag{A-13}$$

Values of K were developed by Chow from theoretical considerations of the normal distribution of logarithms. Chow tabulated values of K for selected probabilities and selected skew coefficients. This tabulation is reproduced as Table A-II. The extreme right hand column in this tables gives values of C_v which, in connection with the coefficient of skew in the first column will produce plotting points of a straight line on log-probability paper.

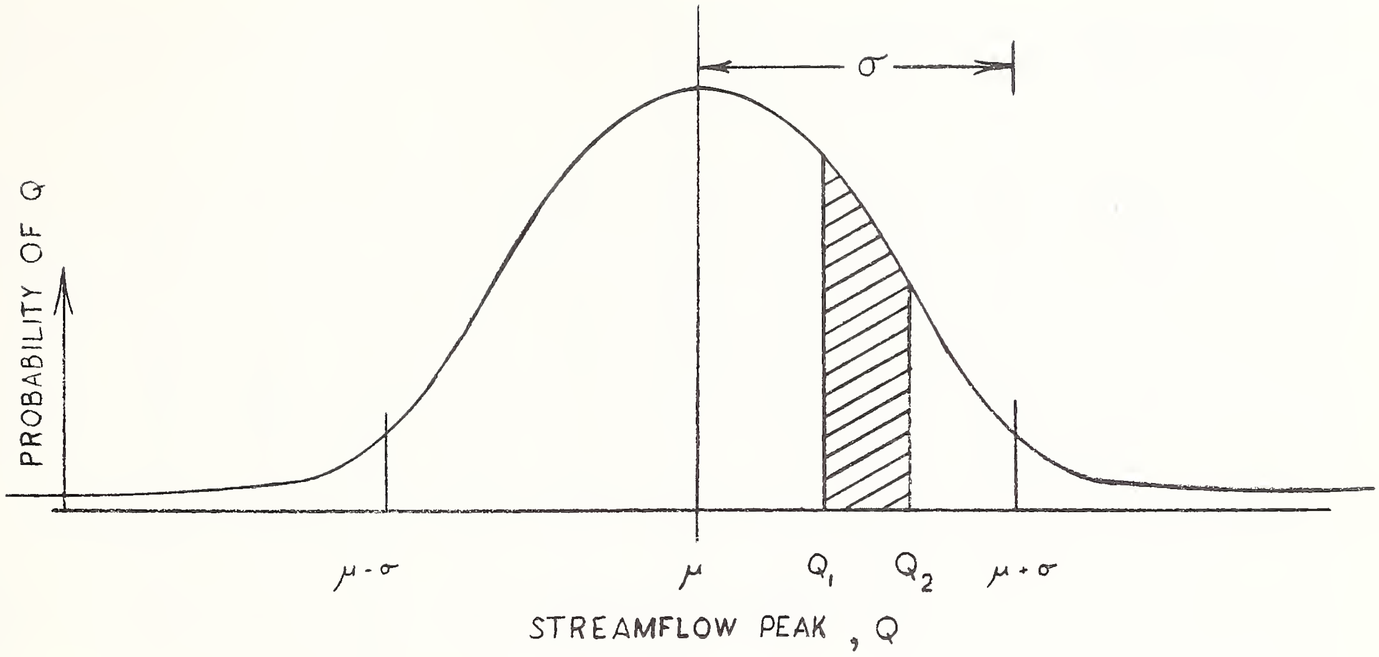


FIGURE A-2. Example of a "normal" distribution.

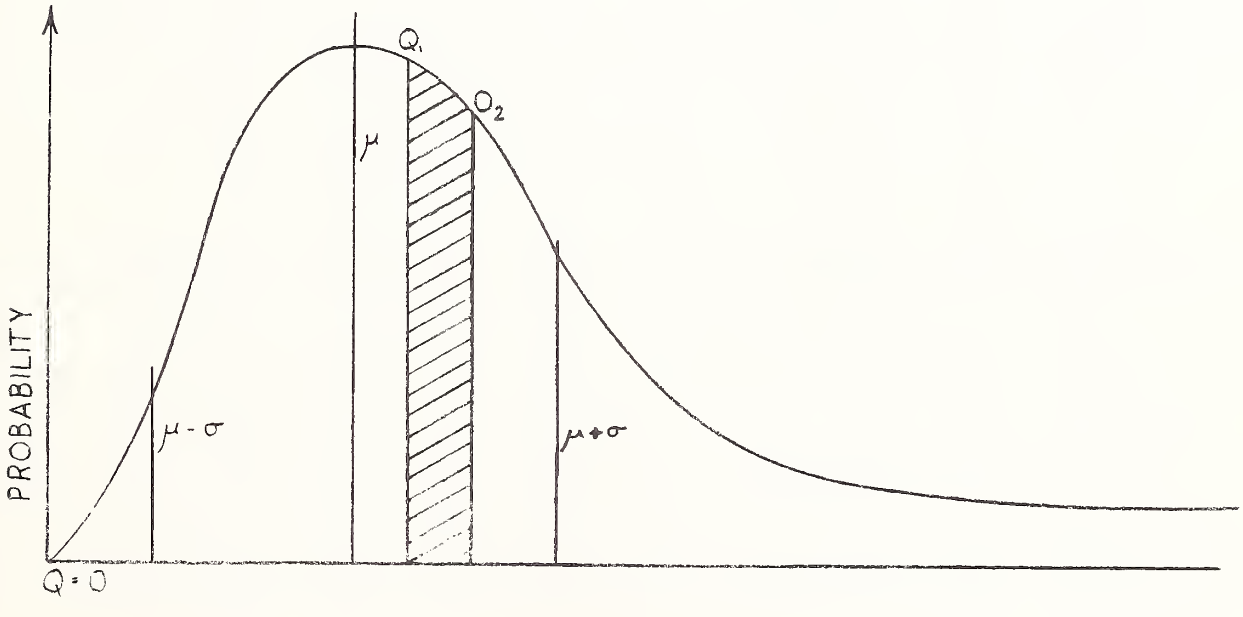


FIGURE A-3. Example of a skew-frequency distribution.

Coefficient of Skew	Probability at Mean	Probability in Percentage Equal to or Greater Than the Given Variate									Corresponding Coefficient of Variation
		99 -	95 -	80 -	50 -	20 +	5 +	1 +	0.1 +	0.01 +	
0	50.0	2.33	1.65	0.84	0	0.84	1.64	2.33	3.09	3.72	0
0.1	49.3	2.25	1.62	0.85	0.02	0.84	1.67	2.40	3.22	3.95	0.033
0.2	48.7	2.18	1.59	0.85	0.04	0.83	1.70	2.47	3.39	4.18	0.067
0.3	48.0	2.11	1.56	0.85	0.06	0.82	1.72	2.55	3.56	4.42	0.100
0.4	47.3	2.04	1.53	0.85	0.07	0.81	1.75	2.62	3.72	4.70	0.136
0.5	46.7	1.98	1.49	0.86	0.09	0.80	1.77	2.70	3.88	4.96	0.166
0.6	46.1	1.91	1.46	0.85	0.10	0.79	1.79	2.77	4.05	5.24	0.197
0.7	45.5	1.85	1.43	0.85	0.11	0.78	1.81	2.84	4.21	5.52	0.230
0.8	44.9	1.79	1.40	0.84	0.13	0.77	1.82	2.90	4.37	5.81	0.262
0.9	44.2	1.74	1.37	0.84	0.14	0.76	1.84	2.97	4.55	6.11	0.292
1.0	43.7	1.68	1.34	0.84	0.15	0.75	1.85	3.03	4.72	6.40	0.324
1.1	43.2	1.63	1.31	0.83	0.16	0.73	1.86	3.09	4.87	6.71	0.351
1.2	42.7	1.58	1.29	0.82	0.17	0.72	1.87	3.15	5.04	7.02	0.381
1.3	42.2	1.54	1.26	0.82	0.18	0.71	1.88	3.21	5.19	7.31	0.409
1.4	41.7	1.49	1.23	0.81	0.19	0.69	1.88	3.26	5.35	7.62	0.436
1.5	41.3	1.45	1.21	0.81	0.20	0.68	1.89	3.31	5.51	7.92	0.462
1.6	40.8	1.41	1.18	0.80	0.21	0.67	1.89	3.36	5.66	8.26	0.490
1.7	40.4	1.38	1.16	0.79	0.22	0.65	1.89	3.40	5.80	8.58	0.517
1.8	40.0	1.34	1.14	0.78	0.22	0.64	1.89	3.44	5.96	8.88	0.544
1.9	39.6	1.31	1.12	0.78	0.23	0.63	1.89	3.48	6.10	9.20	0.570
2.0	39.2	1.28	1.10	0.77	0.24	0.61	1.89	3.52	6.25	9.51	0.596
2.1	38.8	1.25	1.08	0.76	0.24	0.60	1.89	3.55	6.39	9.79	0.620
2.2	38.4	1.22	1.06	0.76	0.25	0.59	1.89	3.59	6.51	10.12	0.643
2.3	38.1	1.20	1.04	0.75	0.25	0.58	1.88	3.62	6.65	10.43	0.667
2.4	37.7	1.17	1.02	0.74	0.26	0.57	1.88	3.65	6.77	10.72	0.691
2.5	37.4	1.15	1.00	0.74	0.26	0.56	1.88	3.67	6.90	10.95	0.713
2.6	37.1	1.12	0.99	0.73	0.26	0.55	1.87	3.70	7.02	11.25	0.734
2.7	36.8	1.10	0.97	0.72	0.27	0.54	1.87	3.72	7.13	11.55	0.755
2.8	36.6	1.08	0.96	0.72	0.27	0.53	1.86	3.74	7.25	11.80	0.776
2.9	36.3	1.06	0.95	0.71	0.27	0.52	1.86	3.76	7.36	12.10	0.796
3.0	36.0	1.04	0.93	0.71	0.28	0.51	1.85	3.78	7.47	12.36	0.818
3.2	35.5	1.01	0.90	0.69	0.28	0.49	1.84	3.81	7.65	12.85	0.857
3.4	35.1	0.98	0.88	0.68	0.29	0.47	1.83	3.84	7.84	13.36	0.895
3.6	34.7	0.95	0.86	0.67	0.29	0.46	1.81	3.87	8.00	13.83	0.930
3.8	34.2	0.92	0.84	0.66	0.29	0.44	1.80	3.89	8.16	14.23	0.966
4.0	33.9	0.90	0.82	0.65	0.29	0.42	1.78	3.91	8.30	14.70	1.000
4.5	33.0	0.84	0.78	0.63	0.30	0.39	1.75	3.93	8.60	15.62	1.081
5.0	32.3	0.80	0.74	0.62	0.30	0.37	1.71	3.95	8.86	16.45	1.155

To use the log-probability method in predicting flood frequencies, mean, standard deviation and coefficient of skew are computed. Values of K from Table A-II are then used to determine peak discharges corresponding to the desired probabilities. The resulting points are plotted on log-probability paper to define the discharge-return frequency curve. Chow suggests that if the predicted line does not satisfactorily fix the recorded data, new values of C_s can be arbitrarily assumed, and K values re-determined. Lower values of C_s result in curves that are increasingly concave upward, while higher values of C_v produce curves that are increasingly concave downard.

Log-Pearson Type III Distribution: The requirement that all U.S. federal agencies are to use this method for predicting flood frequencies (Hydrology Committee, Water Resources Council, 1967) is designed to provide a common basis for evaluating proposed water resource projects; its use does not necessarily imply that it is the correct distribution which applies universally to all hydrologic data.

The basis for the method was advanced by Pearson in 1922 and proposed for use in hydrologic studies by Foster (1924). Actually, Pearson proposed 12 different distributions, but only his Type III has received serious consideration. Beard, (1962) described the logarithmic transformations which produce the distribution now termed Log-Pearson Type III.

In using this distribution the mean, standard deviation and coefficient of skew are computed as before, but using logarithms of recorded discharges instead of the recorded values themselves. For the computed coefficient of skew and desired probabilities, values of the frequency factor K are determined from Table A-III, and these values used to determine log Q in

$$\text{Log } Q = M + kS \qquad \text{(A-14)}$$

where M is mean of logarithms of recorded discharges

S is standard deviation of logarithms of recorded discharges.

The probability values in Table A-III are only valid for infinitely long periods of record. It is necessary therefore to adjust the probabilities depending on the length of record, using Table A-IV.

Extreme Value Distribution: Fisher and Tippett (1928) showed that if one selected the largest event from each of many large samples, the distribution of these extreme events was independent of the original distribution and conformed to a limiting function. In 1941 Gumbel suggested fitting the extreme value distribution to flood data, because the annual flood could be assumed to be the largest of a sample of 365 possible values each year. The resulting techniques are referred to as the "extreme value" or "Gumbel" distribution.

Fisher-Tippett argued that the limiting distribution was of the form of a double-exponential,

$$P_x = e^{-e^{-y}} \qquad \text{(A-15)}$$

where P_x = probability that a given value of x (peak discharge, for instance)

TABLE A-III: PEARSON TYPE III COORDINATES

g (Skew coefficient)	k = Magnitude in standard deviations from mean for exceedance percentages of:												
	0.01	0.1	1.0	5	10	30	50	70	90	95	99	99.9	99.99
1.0	5.92	4.54	3.03	1.87	1.34	0.38	-0.16	-0.61	-1.12	-1.31	-1.59	-1.80	-1.88
0.8	5.48	4.25	2.90	1.83	1.34	0.42	-0.13	-0.60	-1.16	-1.38	-1.74	-2.03	-2.18
0.6	5.04	3.96	2.77	1.79	1.33	0.45	-0.09	-0.58	-1.19	-1.45	-1.88	-2.28	-2.53
0.4	4.60	3.67	2.62	1.74	1.32	0.48	-0.06	-0.57	-1.22	-1.51	-2.03	-2.54	-2.92
0.2	4.16	3.38	2.48	1.69	1.30	0.51	-0.03	-0.55	-1.25	-1.58	-2.18	-2.81	-3.32
0.0	3.73	3.09	2.33	1.64	1.28	0.52	0.00	-0.52	-1.28	-1.64	-2.33	-3.09	-3.73
-0.2	3.32	2.81	2.18	1.58	1.25	0.55	0.03	-0.51	-1.30	-1.69	-2.48	-3.38	-4.16
-0.4	2.92	2.54	2.03	1.51	1.22	0.57	0.06	-0.48	-1.32	-1.74	-2.62	-3.67	-4.60
-0.6	2.53	2.28	1.88	1.45	1.19	0.58	0.09	-0.45	-1.33	-1.79	-2.77	-3.96	-5.04
-0.8	2.18	2.03	1.74	1.38	1.16	0.60	0.13	-0.42	-1.34	-1.83	-2.90	-4.25	-5.48
-1.0	1.88	1.80	1.59	1.31	1.12	0.61	0.16	-0.38	-1.34	-1.87	-3.03	-4.54	-5.92
Skew Coefficients Commonly Used													
.00	3.73	3.09	2.33	1.64	1.28	0.52	0.00	-0.52	-1.28	-1.64	-2.33	-3.09	-3.73
-.04	3.65	3.03	2.30	1.63	1.27	0.53	0.01	-0.52	-1.28	-1.65	-2.36	-3.15	-3.82
-.12	3.48	2.92	2.24	1.60	1.26	0.54	0.02	-0.51	-1.29	-1.67	-2.42	-3.26	-3.99
-.23	3.26	2.77	2.16	1.56	1.25	0.55	0.03	-0.50	-1.30	-1.70	-2.50	-3.42	-4.23
-.32	3.08	2.68	2.09	1.54	1.23	0.56	0.05	-0.49	-1.31	-1.72	-2.56	-3.55	-4.42
-.37	2.98	2.58	2.05	1.52	1.22	0.57	0.06	-0.48	-1.32	-1.73	-2.60	-3.63	-4.53
-.40	2.92	2.54	2.03	1.51	1.22	0.56	0.06	-0.48	-1.32	-1.74	-2.62	-3.67	-4.60

Note: Approximate transformations between normal deviate (X) and Pearson Type III deviate k can be accomplished with the following equation:

$$k = \frac{2}{g}\left\{\left[\frac{g}{6}\;X - \frac{g}{6} + 1\right]^{3} - 1\right\}$$

TABLE A-IV: TABLE OF P_N VERSUS P_∞ IN PERCENT

For use with samples drawn from a normal population

N-1 \ P_∞	50.0	30.0	10.0	5.0	1.0	0.1	0.01
1	50.0	37.2	24.3	20.4	15.4	12.1	10.2
2	50.0	34.7	19.3	14.6	9.0	5.7	4.3
3	50.0	33.6	16.9	11.9	6.4	3.5	2.3
4	50.0	33.0	15.4	10.4	5.0	2.4	1.37
5	50.0	32.5	14.6	9.4	4.2	1.79	.92
6	50.0	32.2	13.8	8.8	3.6	1.38	.66
7	50.0	31.9	13.5	8.3	3.2	1.13	.39
8	50.0	31.7	13.1	7.9	2.9	.94	.39
9	50.0	31.6	12.7	7.6	2.7	.82	.31
10	50.0	31.5	12.5	7.3	2.5	.72	.25
11	50.0	31.4	12.3	7.1	2.3	.64	.21
12	50.0	31.3	12.1	6.9	2.2	.58	.18
13	50.0	31.2	11.9	6.8	2.1	.52	.16
14	50.0	31.1	11.8	6.7	2.0	.48	.14
15	50.0	31.1	11.7	6.6	1.96	.45	.13
16	50.0	31.0	11.6	6.5	1.90	.42	.12
17	50.0	31.0	11.5	6.4	1.84	.40	.11
18	50.0	30.9	11.4	6.3	1.79	.38	.10
19	50.0	30.9	11.3	6.2	1.74	.36	.091
20	50.0	30.8	11.3	6.2	1.70	.34	.084
21	50.0	30.8	11.2	6.1	1.67	.33	.078
22	50.0	30.8	11.1	6.1	1.63	.31	.073
23	50.0	30.7	11.1	6.0	1.61	.30	.068
24	50.0	30.7	11.0	6.0	1.58	.29	.064
25	50.0	30.7	11.0	5.9	1.55	.28	.060
26	50.0	30.6	10.9	5.9	1.53	.27	.057
27	50.0	30.6	10.9	5.9	1.51	.26	.054
28	50.0	30.6	10.9	5.8	1.49	.26	.051
29	50.0	30.6	10.8	5.8	1.47	.25	.049
30	50.0	30.6	10.8	5.8	1.45	.24	.046
40	50.0	30.4	10.6	5.6	1.33	.20	.034
60	50.0	30.3	10.4	5.4	1.22	.16	.025
120	50.0	30.2	10.2	5.2	1.11	.13	.017
∞	50.0	30.0	10.0	5.0	1.00	.10	.010

NOTE: P_N values above are usable approximately with Pearson Type III distributions having small skew coefficients.

will not be equalled or exceeded.

e = base of naperian logarithms

y = a function of x (referred to as a reduced variate)

Depending on the relationship that exists between x and y, the distribution was categorized by Fisher-Tippett into three types.

Type I - for unbounded data ranging from $-\infty$ to $+\infty$

Type II - data with a lower bound

Type III - data with an upper bound

For the asymptotic distribution of Type I, Gumbel (1964) developed the equation relating the variable x to its reduced variate y, as

$$y = \quad (x - u). \tag{A-16}$$

In this equation u is a "location parameter" given by

$$u = \bar{x} - \frac{y_n}{\alpha} \tag{A-17}$$

and α is a scale parameter or measure of dispersion given by

$$\alpha = \frac{\sigma_n}{S_x} \tag{A-18}$$

Here $\bar{X}$ = mean of the sample

Y_n = expected mean of the population

S_x = standard deviation of the sample

σ_n = expected standard deviation of the population

Eliminating u and α in equation A-16 gives

$$y = \frac{\sigma_n}{S_x}(x - \bar{x}) + \bar{y}_n \qquad \text{(A-19)}$$

Gumbel developed formulas for obtaining $\bar{y}_n$ and σ_n (functions of the length of record), and provided tables with values of $\bar{y}_n$ and σ_n for N (number of extreme events) ranging from 15 to 1000. (See Table A-V).

A computer solution of equation A-15, $P = 1 - e^{-e^{-y}}$ is shown in Table A-VI, where y values are tabulated against recurrence interval ($t_p = \frac{1}{P}$).

In using the "Gumbel" distribution for determining flood frequencies then, the steps are as follows:

1. Compute sample mean and standard deviation.
2. Depending on number of years of record, use Table A-V to obtain expected mean and expected standard deviation.
3. For desired recurrence intervals, use Table A-VI to obtain corresponding values of y.
4. For each value of y solve equation A-19 (repeated below in terms of discharge) to obtain required peak discharge corresponding to each recurrence interval.

$$Q = \bar{Q} + \frac{S_q}{\sigma_n}(y - \bar{y}_n) \qquad \text{(A-20)}$$

TABLE A-V: EXPECTED MEAN $\bar{y}_N$, AND EXPECTED STANDARD DEVIATION σ_N AS FUNCTIONS OF THE NUMBER OF EXTREMES N

Number of Extremes, N	Expected Mean $\bar{y}_N$	Expected Standard Deviation σ_N
10	0.50213	0.97831
15	0.51284	1.02057
20	0.52355	1.06283
25	0.53086	1.09145
30	0.53622	1.11238
35	0.54034	1.12847
40	0.54362	1.14132
45	0.54630	1.15185
50	0.54854	1.16066
60	0.55208	1.17467
70	0.55477	1.18536
80	0.55688	1.19382
90	0.55860	1.20073
100	0.56002	1.20649
150	0.56461	1.22534
200	0.56715	1.23598
250	0.56878	1.24292
300	0.56993	1.24786
400	0.57144	1.25450
500	0.57240	1.25880
750	0.57377	1.26506
1000	0.57450	1.26851

TABLE A-VI: PLOTTING COORDINATES FOR PROBABILITY PAPER

t_p	y
1.01	-1.5293
1.02	-1.3691
1.03	-1.2630
1.04	-1.1811
1.05	-1.1133
1.10	-0.8745
1.15	-0.7114
1.20	-0.5831
1.25	-0.4758
1.30	-0.3827
1.40	-0.2253
1.50	-0.0940
1.60	0.0193
1.70	0.1195
1.80	0.2095
1.90	0.2914
2.00	0.3665
2.20	0.5006
2.40	0.6180
2.60	0.7225
2.80	0.8168
3.00	0.9027
3.20	0.9816
3.40	1.0546
3.60	1.1226
3.80	1.1861
4.00	1.2458
4.50	1.3810
5.00	1.4999
5.50	1.6060
6.00	1.7019
6.50	1.7894
7.00	1.8698
7.50	1.9442
8.00	2.0134
9.00	2.1389
10.00	2.2503
11.00	2.3506
12.00	2.4417
13.00	2.5251
14.00	2.6022
15.00	2.6737
20.00	2.9701
25.00	3.1985
30.00	3.3842
35.00	3.5408
40.00	3.6762
45.00	3.7954
50.00	3.9019
60.00	4.0859
70.00	4.2413
80.00	4.3757
90.00	4.4942
100.00	4.6001
120.00	4.7833
140.00	4.9380
160.00	5.0720
180.00	5.1901
200.00	5.2958
220.00	5.3913
240.00	5.4785
260.00	5.5587
280.00	5.6330
300.00	5.7021
350.00	5.8565
400.00	5.9902
450.00	6.1081
500.00	6.2136
600.00	6.3961
700.00	6.5504
800.00	6.6839
900.00	6.8018
1000.00	6.9072

Chow has shown that the extreme value distribution is really essentially a special case of the log-probability law where the skew coefficient is 1.139, and coefficient of variation is 0.364.

The "Gumbel" distribution has been widely publicized in hydrology textbooks and is frequently used today.

In order to minimize bias involved in the prediction of extremes, Lieblein (1954) suggested a method to fix the extreme value distribution which preserves the original time order of occurrence of events.

I. I. Gringorten (1962) suggested that no single distribution can be expected to fit all meteorological data universally. He developed seven "type curves",to which recorded data are compared, and the distribution best fitting the data is thereby selected. Four of the curves are essentially "normal distribution" curves. Curve 1 is the basic normal distribution; curve 2 is the distribution of the largest of 10 members taken independently from a normal distribution; 3 and 4 are the distributions of the largest of 100 and 1000 members respectively, taken independently from a normal distribution. Curve 5 is the double exponential distribution, while 6 and 7 are versions of the Fisher-Tippett Type II distribution.

The fundamental equations governing the family of Gringorten curves can be stated as

$$x = \bar{x} + \sigma_x y_r \qquad \text{(A-21)}$$

where $y_r = (y - \hat{y})/\sigma_y$ (A-22)

In these equations x = estimate of the variable

$\bar{x}$ = true mean of x

σ_x = true standard deviation of x

y = standardized value of idealized variate

$\tilde{y}$ = true mean of y

σ_y = true standard deviation of y.

Figure A-4 shows the type curves, while Table A-VII gives descriptions of the curves and their characteristic features.

Hydrologic Simulation

In the last few years the rapid development of mathematical statistics and the digital computer have made it possible to generate hypothetical sequences of events which have the same probability characteristics as the historic record, and thereby permit the consideration of many possible combinations of output. Probably the best-known simulation analysis to date is that the Harvard Program, as reported by Maass, et al (1966). With 32 years of record available for the Clearwater River in Idaho, a 500-year streamflow sequence was generated by mathematical synthesis.

Several stochastic models have been proposed for simulation, falling into one of two general categories. If the individual items of data are considered statistically independent (that is, the state of the system at a

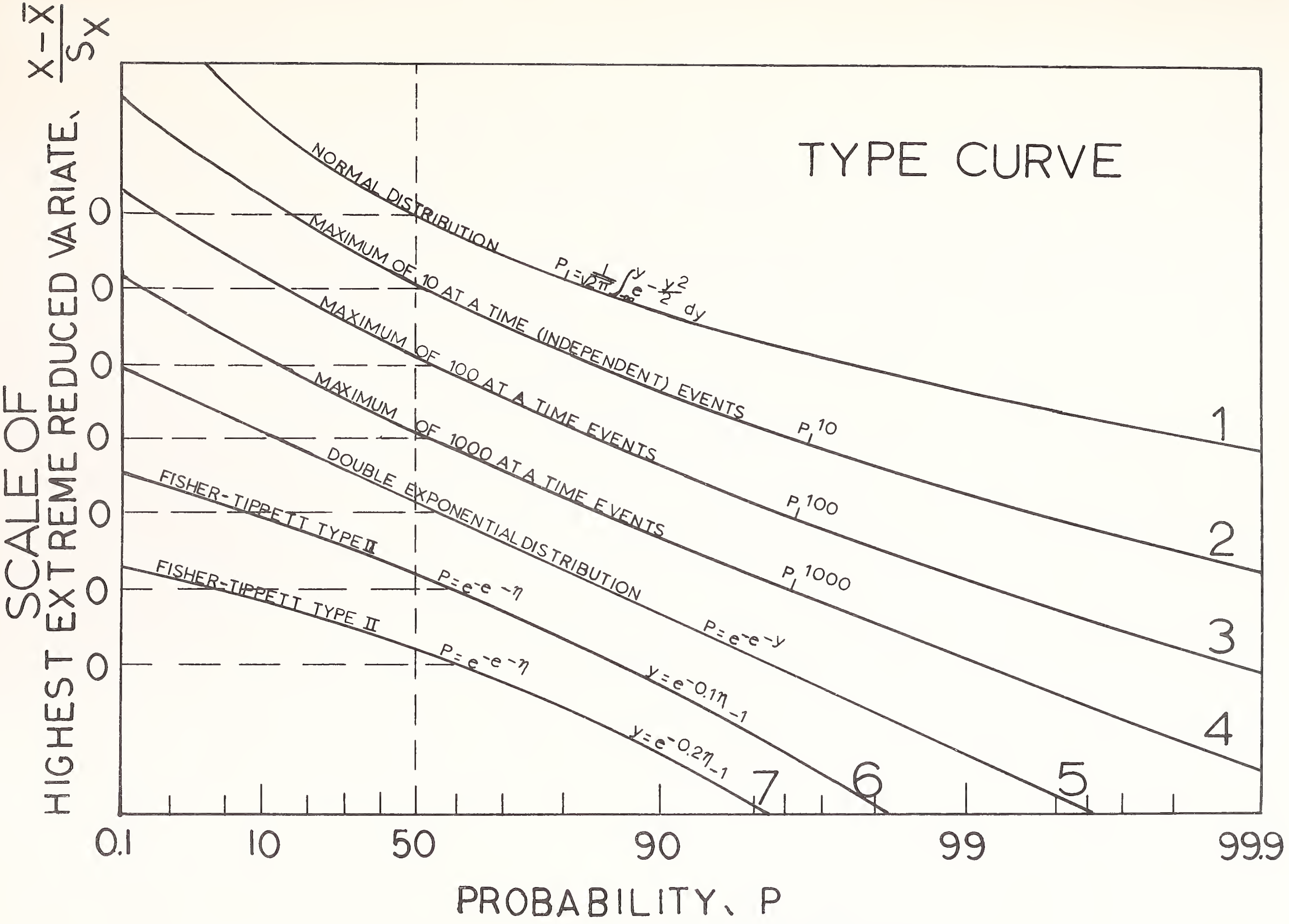


FIGURE A-4. Seven Gringorten "Type" Curves as Functions of Probability.

TABLE A-VII: CHARACTERISTIC FEATURES OF DISTRIBUTIONS DESCRIBED BY GRINGORTEN'S FAMILY OF CURVES, NOS. 1 THROUGH 7

Curve No. (i)	Mean $\bar{Y}_i$	Standard Deviation $_i$	Distribution	Equation of the Cumulative Distribution of 'Y'
1	0	1	Basic Gaussian or Normal Distribution	$P(y) = \frac{1}{\sqrt{2\pi}} \int_{-\infty} e^{-y^2/2} \, dy = P_1$
2	1.5388	0.5868	Distribution of the largest of 10 members taken independently from a normal distribution	$P(y) = P_1^{10}$
3	2.5076	0.4294	Distribution of the largest of 100 members taken independently from a normal distribution	$P(y) = P_1^{100}$
4	3.2414	0.3514	Distribution of the largest of 1000 members taken independently from a normal distribution	$P(y) = P_1^{1000}$
5	0.5772	1.28255	Double-exponential distribution	$P(y) = e^{-e^{-y}}$
6	0.0686	0.1494	Fisher-Tippett distribution with a lower bound: Type II	$P(y) = e^{-e^{-\eta}}$ where $y = e^{(0.1\eta)} - 1$
7	0.1642	0.3660	Fisher-Tippett distribution with a lower bound: Type II	$P(y) = e^{-e^{-\eta}}$ where $y = e^{(0.2\eta)} - 1$

given time is not dependent upon previous states) the process is said to be "non-Markovian," and the usual treatment is application of Monte Carlo methods. If there are carry-over effects (the streamflow at one time, for instance, being dependent upon the streamflow at an earlier time) the Monte Carlo methods cannot be applied directly, and use of transition probability theory is usually used instead. Transition probability is developed under the general theory of Markov processes.

Monte Carlo methods - After studying the characteristics of the distribution of recorded data an appropriate sampling technique, involving the use of tables of random numbers, is used to produce artificial sequences having the same stochastic structure as the record. Fiering (1967) used Monte Carlo techniques in studying the Lehigh River basin in Pennsylvania.

Markov Processes - A sample expression of a Markov model is

$$y_t = p_1 y_{\tau-1} + \eta \bar{E} \tag{A-23}$$

where y_t = runoff at time t

$y_{\tau-1}$ = runoff at time $\tau - 1$

p_1 = constant

η = constant dependent on the distribution of the recorded runoff data

$\bar{E}$ = a random variable

The coefficients must be properly chosen so that the simulated sequences will have the same stochastic properties as the recorded series. Additional sophistication may be obtained by adding terms (i.e., $p_2\, y_{\tau-2}$, $p_3 y_{\tau-3}$, etc.).

Amorocho and Hart suggest that there is no clearcut way to decide, in general, whether to assume no time dependence and use Monte Carlo methods directly, or whether to assume simple or complex time dependence.

SUMMARY

The purpose of this chapter has been to describe the current techniques available for determining peak discharge and associated frequency. The parametric methods permit calculation of discharge peak, but do not suggest a return frequency or probability. In using parametric methods a frequency may be assigned to a causative storm, and this will permit indirectly the determination of peak flow frequency. Stochastic methods use the statistical characteristics of the recorded data, precipitation, or streamflow.

APPENDIX B

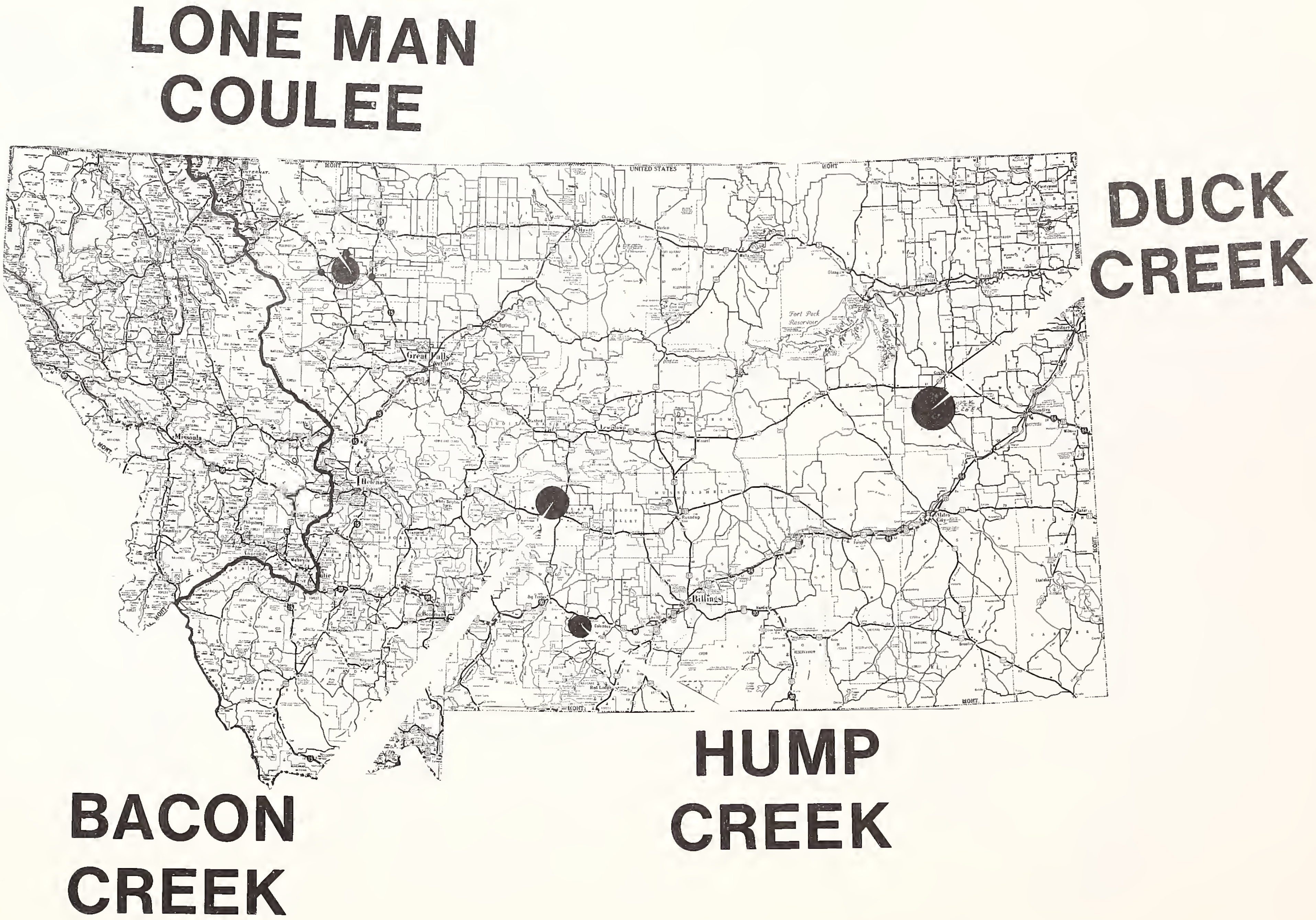
1. Map of Montana Showing Instrumented Watersheds

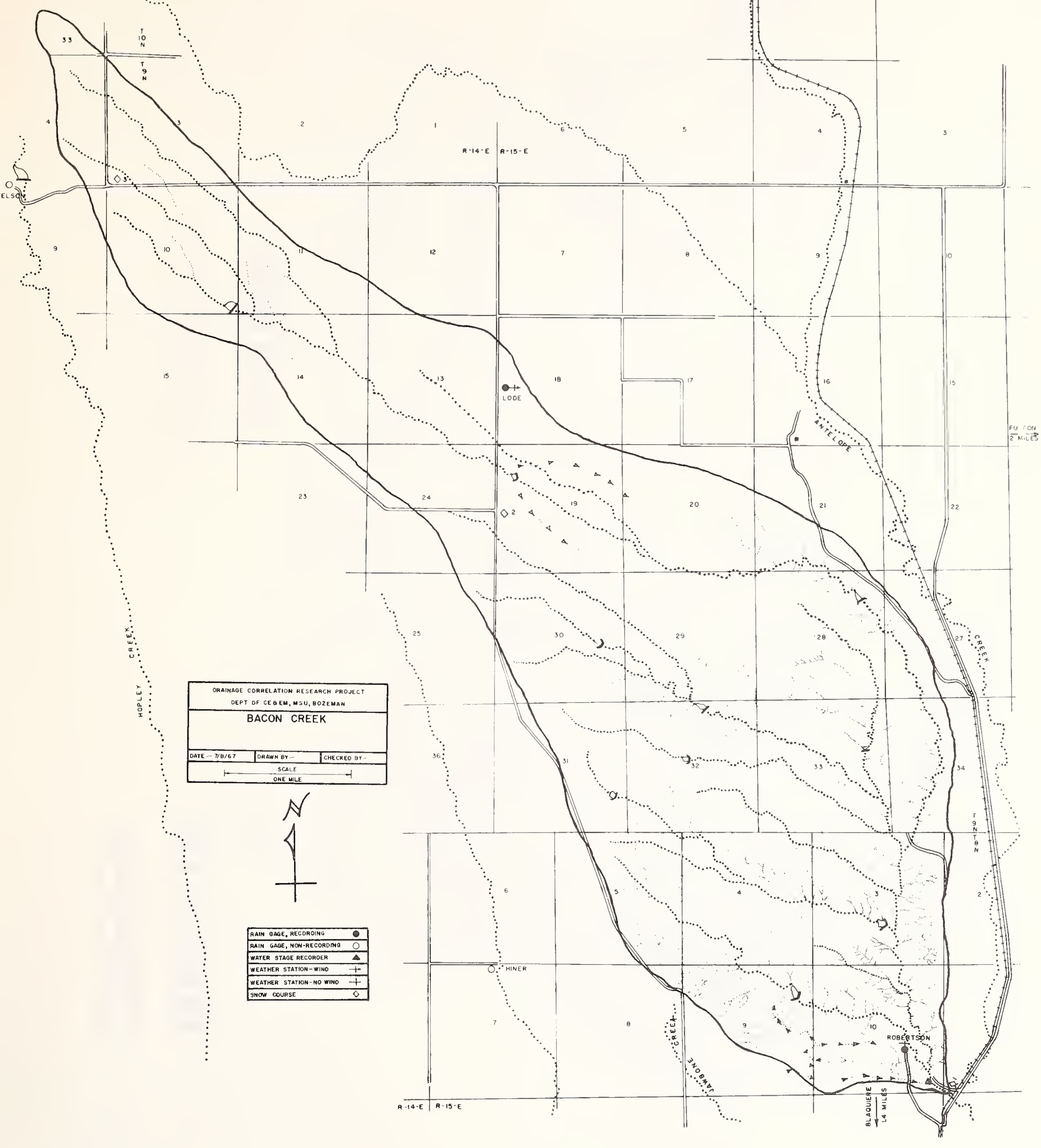
2. Maps of Instrumented Watersheds

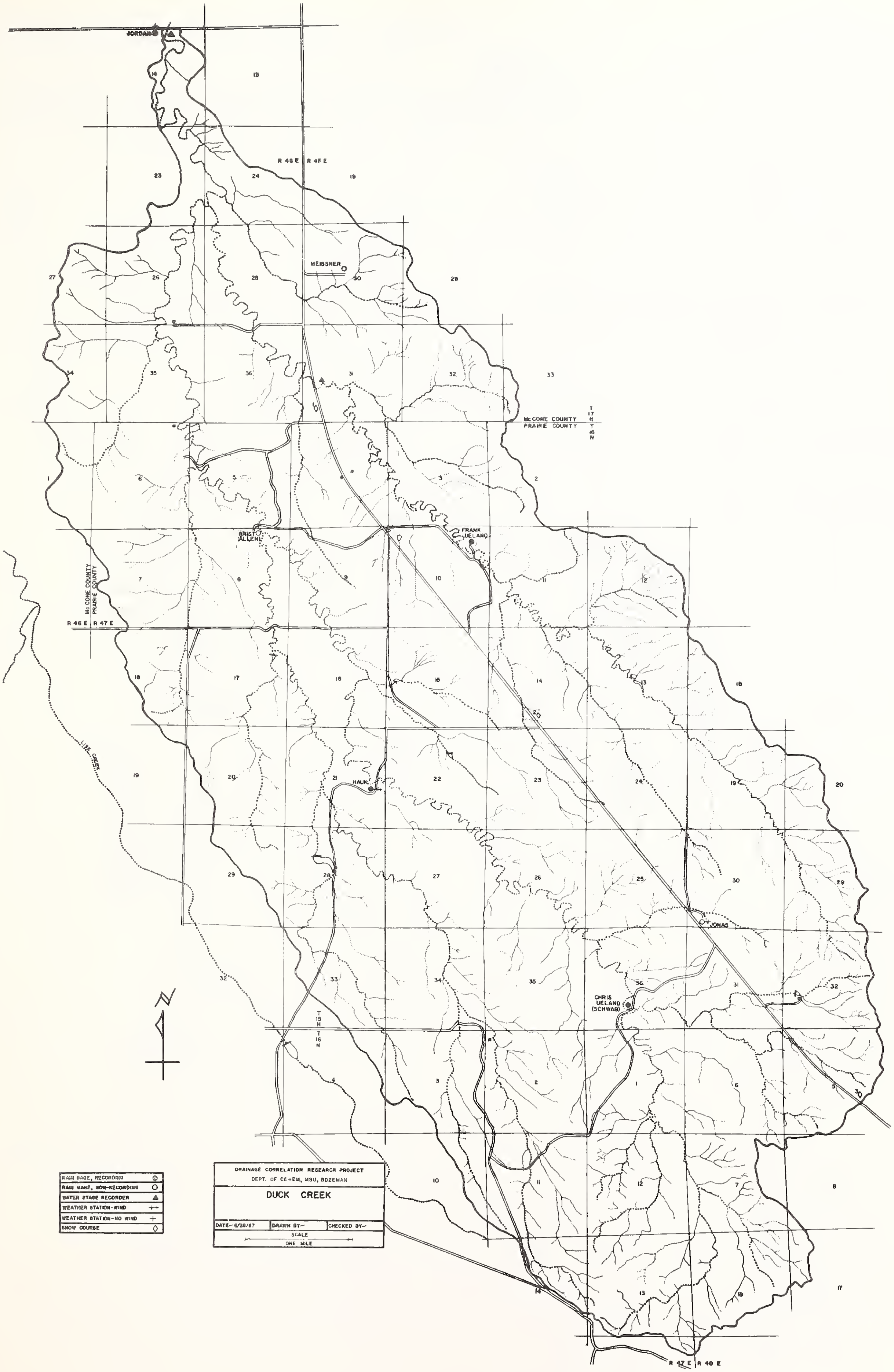
   a. Bacon Creek
   b. Duck Creek
   c. Hump Creek
   d. Lone Man Coulee

3. Aerial Photographs of Instrumented Watersheds

   a. Bacon Creek looking Northwest
   b. Bacon Creek looking Southeast
   c. Duck Creek looking South
   d. Duck Creek looking North
   e. Hump Creek looking South
   f. Hump Creek looking North
   g. Lone Man Coulee looking West
   h. Lone Man Coulee looking East


LONE MAN COULEE
DUCK CREEK
BACON CREEK
HUMP CREEK

DRAINAGE CORRELATION RESEARCH PROJECT
DEPT OF CE & EM, MSU, BOZEMAN
BACON CREEK
DATE — 7/8/67
DRAWN BY —
CHECKED BY —
SCALE
ONE MILE
RAIN GAGE, RECORDING ●
RAIN GAGE, NON-RECORDING ○
WATER STAGE RECORDER ▲
WEATHER STATION - WIND
WEATHER STATION - NO WIND
SNOW COURSE ◇
NELSON
LODE
HINER
ROBERTSON
HOPLEY CREEK
JAWBONE CREEK
ANTELOPE CREEK
BLAQUIERE 14 MILES
FULTON 2 MILES
R-14-E R-15-E
T 10 N
T 9 N
T 8 N
2
3


JORDAN
R 46 E
R 47 E
R 48 E
MEISSNER
McCONE COUNTY
PRAIRIE COUNTY
T 17 N
T 16 N
T 15 N
BRISTO (ALLEN)
FRANK UELAND
HAUK
JONAS
CHRIS UELAND (SCHWAB)
LINK CREEK
N
RAIN GAGE, RECORDING
RAIN GAGE, NON-RECORDING
WATER STAGE RECORDER
WEATHER STATION-WIND
WEATHER STATION-NO WIND
SNOW COURSE
DRAINAGE CORRELATION RESEARCH PROJECT
DEPT. OF CE+EM, MSU, BOZEMAN
DUCK CREEK
DATE-6/28/67
DRAWN BY-
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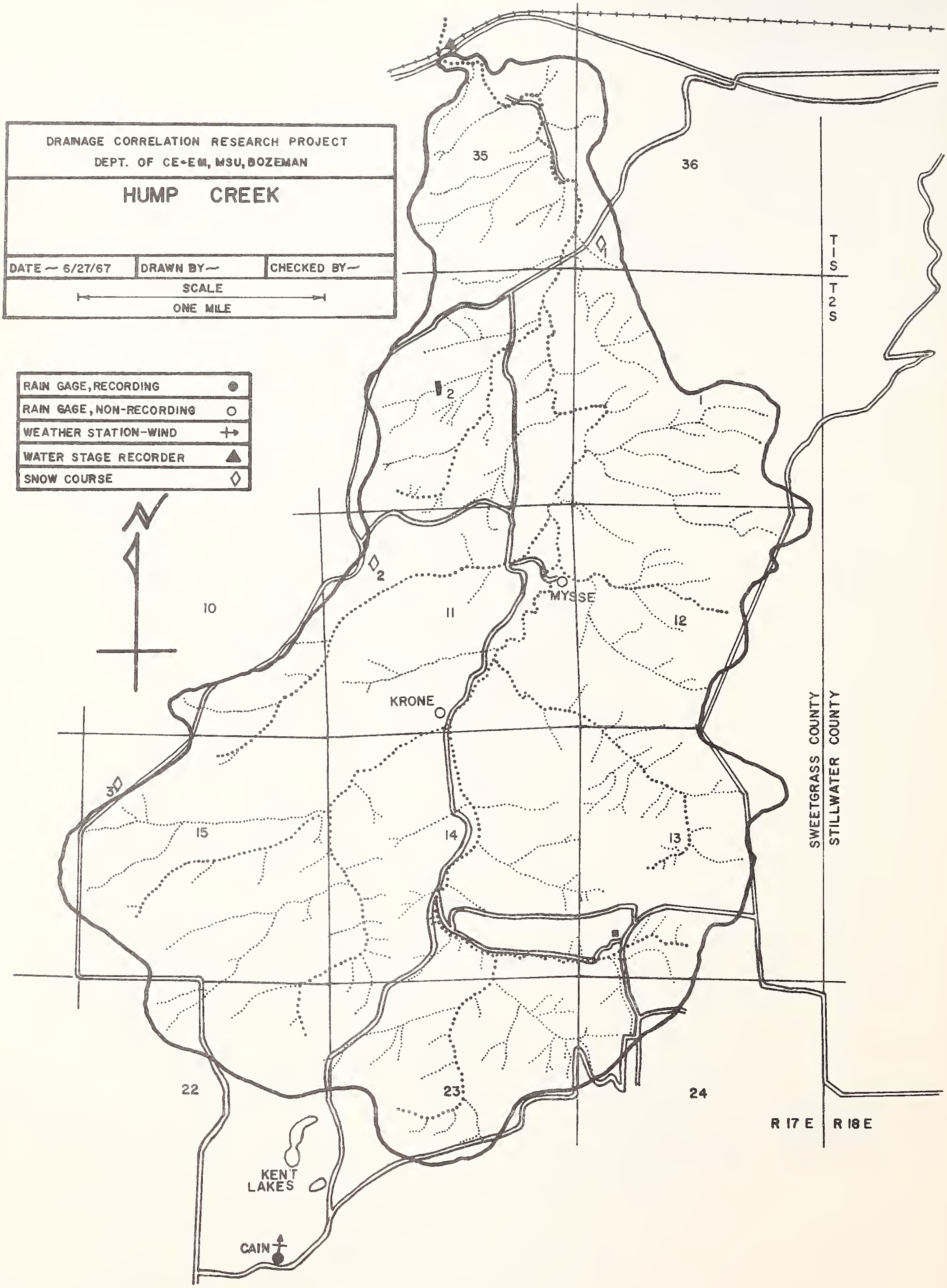
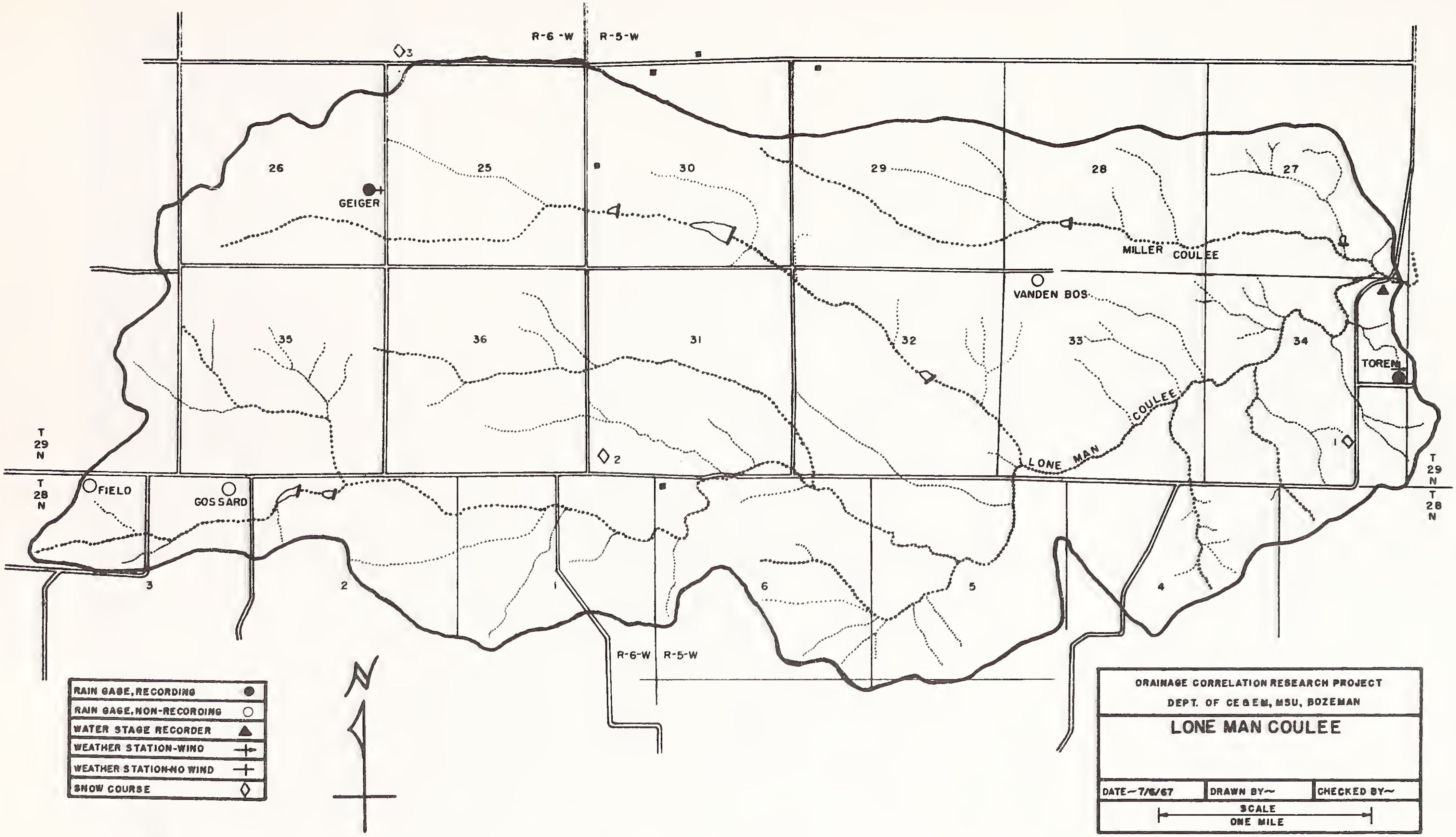
SCALE
ONE MILE


DRAINAGE CORRELATION RESEARCH PROJECT
DEPT. OF CE+EM, MSU, BOZEMAN
HUMP CREEK
DATE — 6/27/67
DRAWN BY—
CHECKED BY—
SCALE
ONE MILE
RAIN GAGE, RECORDING ●
RAIN GAGE, NON-RECORDING ○
WEATHER STATION-WIND
WATER STAGE RECORDER ▲
SNOW COURSE ◇
N
35
36
1
2
2
10
11
MYSSE
12
KRONE
3
15
14
13
22
23
24
KENT LAKES
CAIN
T 1 S
T 2 S
SWEETGRASS COUNTY
STILLWATER COUNTY
R 17 E
R 18 E


R-6-W
R-5-W
T 29 N
T 28 N
26
25
30
29
28
27
35
36
31
32
33
34
3
2
1
6
5
4
GEIGER
MILLER COULEE
VANDEN BOS
TOREN
LONE MAN COULEE
FIELD
GOSSARD
◇3
◇2
1 ◇
RAIN GAGE, RECORDING ●
RAIN GAGE, NON-RECORDING ○
WATER STAGE RECORDER ▲
WEATHER STATION-WIND
WEATHER STATION-NO WIND
SNOW COURSE ◇
N
DRAINAGE CORRELATION RESEARCH PROJECT
DEPT. OF CE & EM, MSU, BOZEMAN
LONE MAN COULEE
DATE—7/6/67
DRAWN BY—
CHECKED BY—
SCALE
ONE MILE

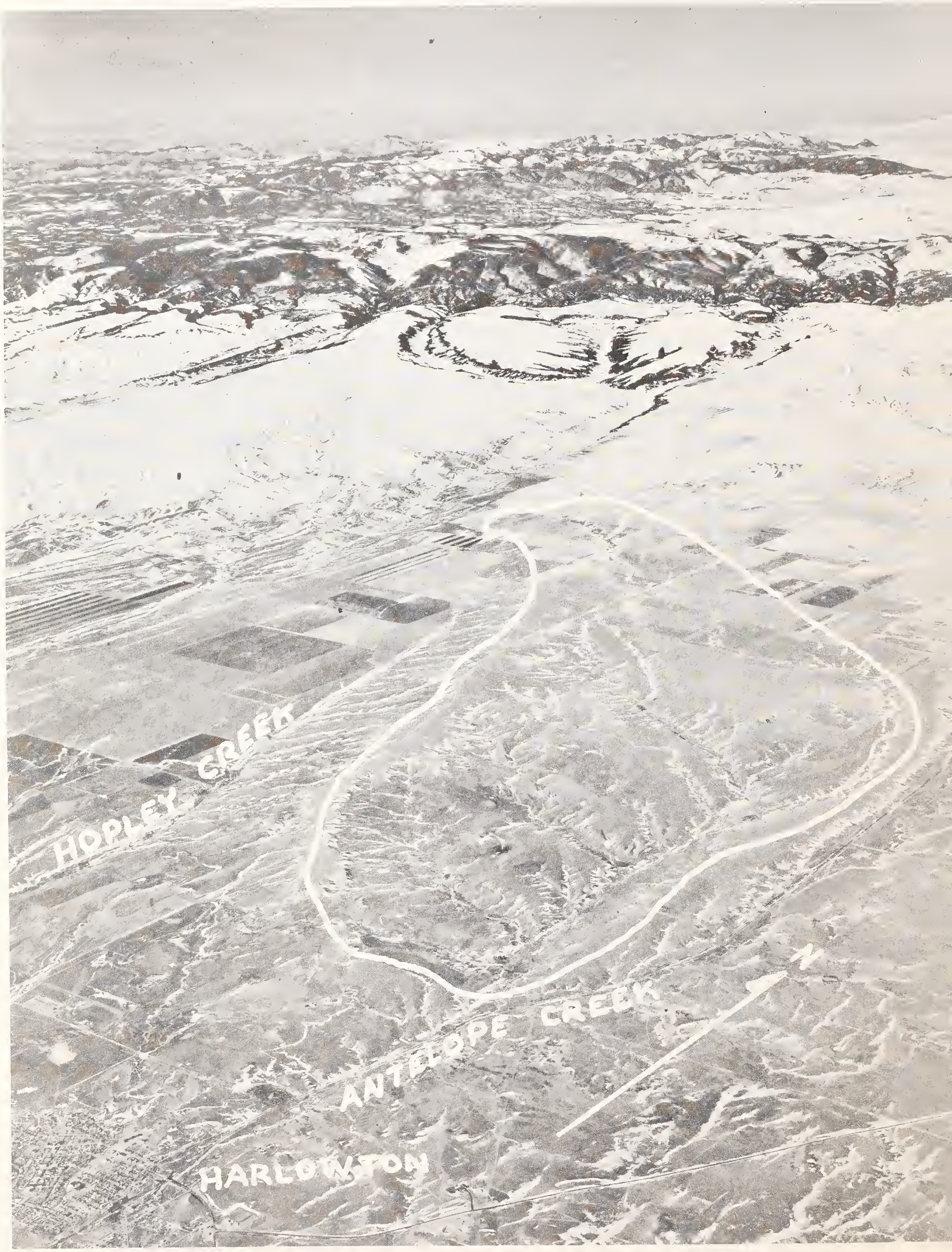


FIGURE B-1: Bacon Creek, looking Northwest

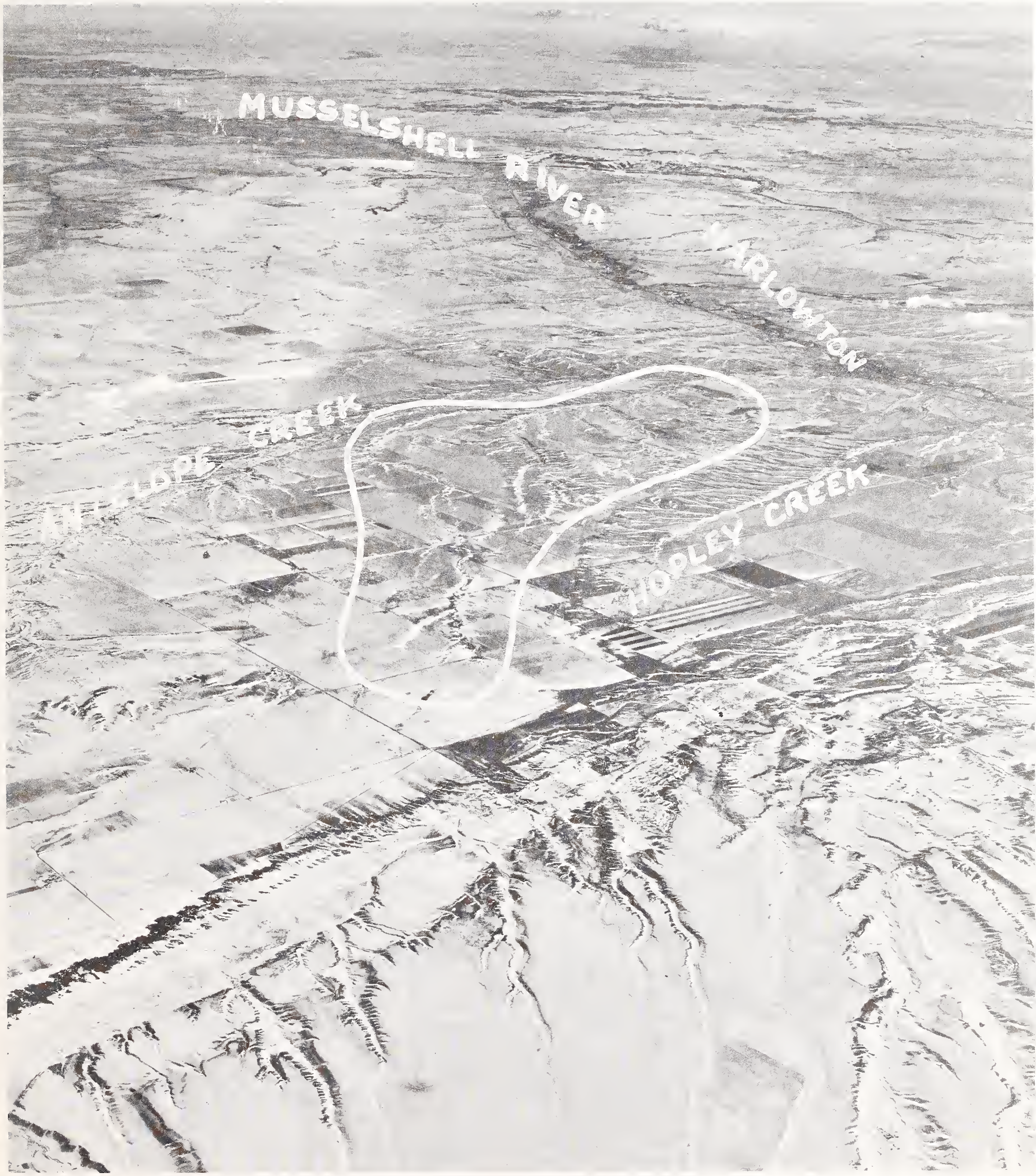


FIGURE B-2: Bacon Creek, looking Southeast

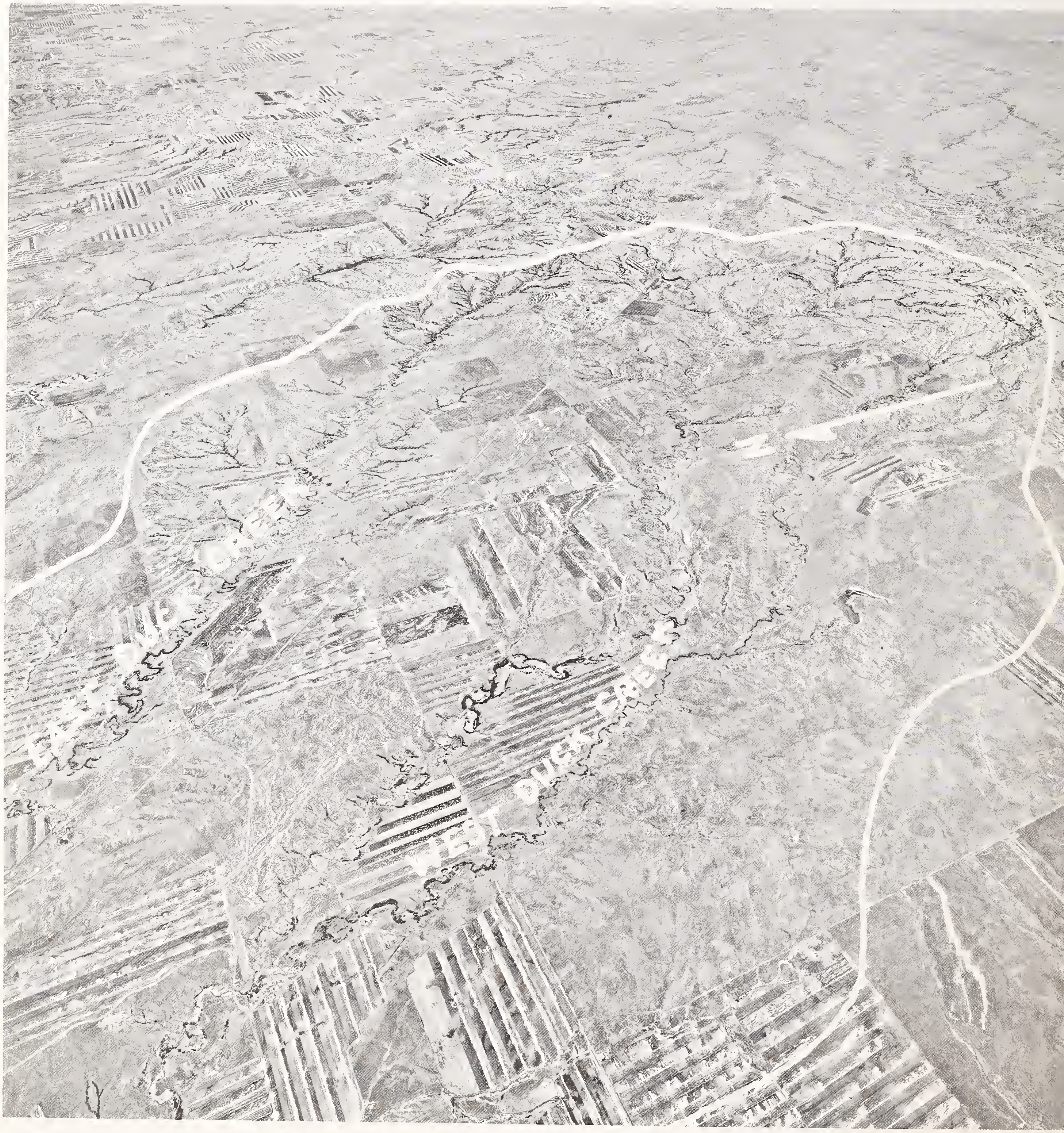


FIGURE B-3: Duck Creek, looking South

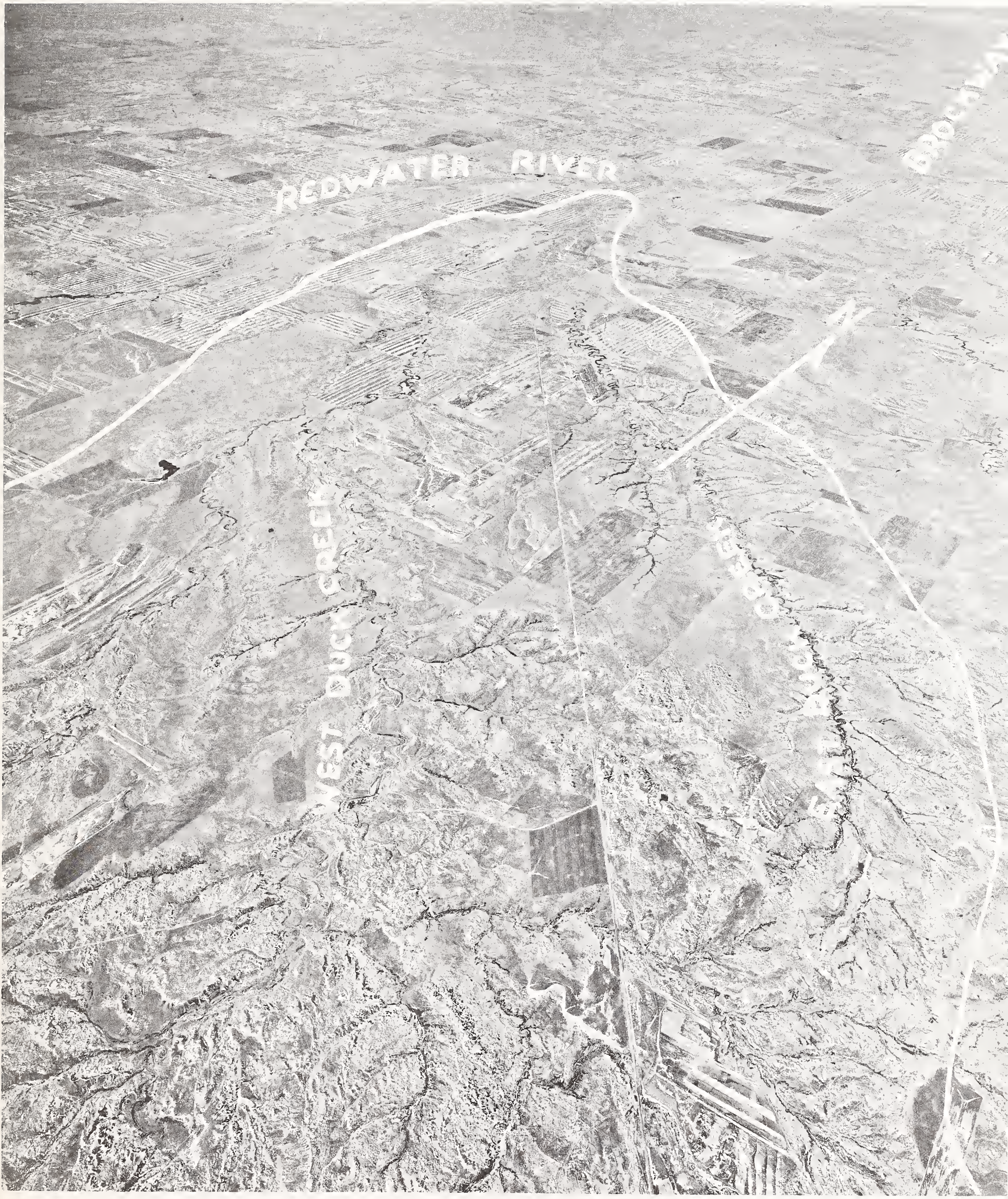


FIGURE B-4: Duck Creek, looking North

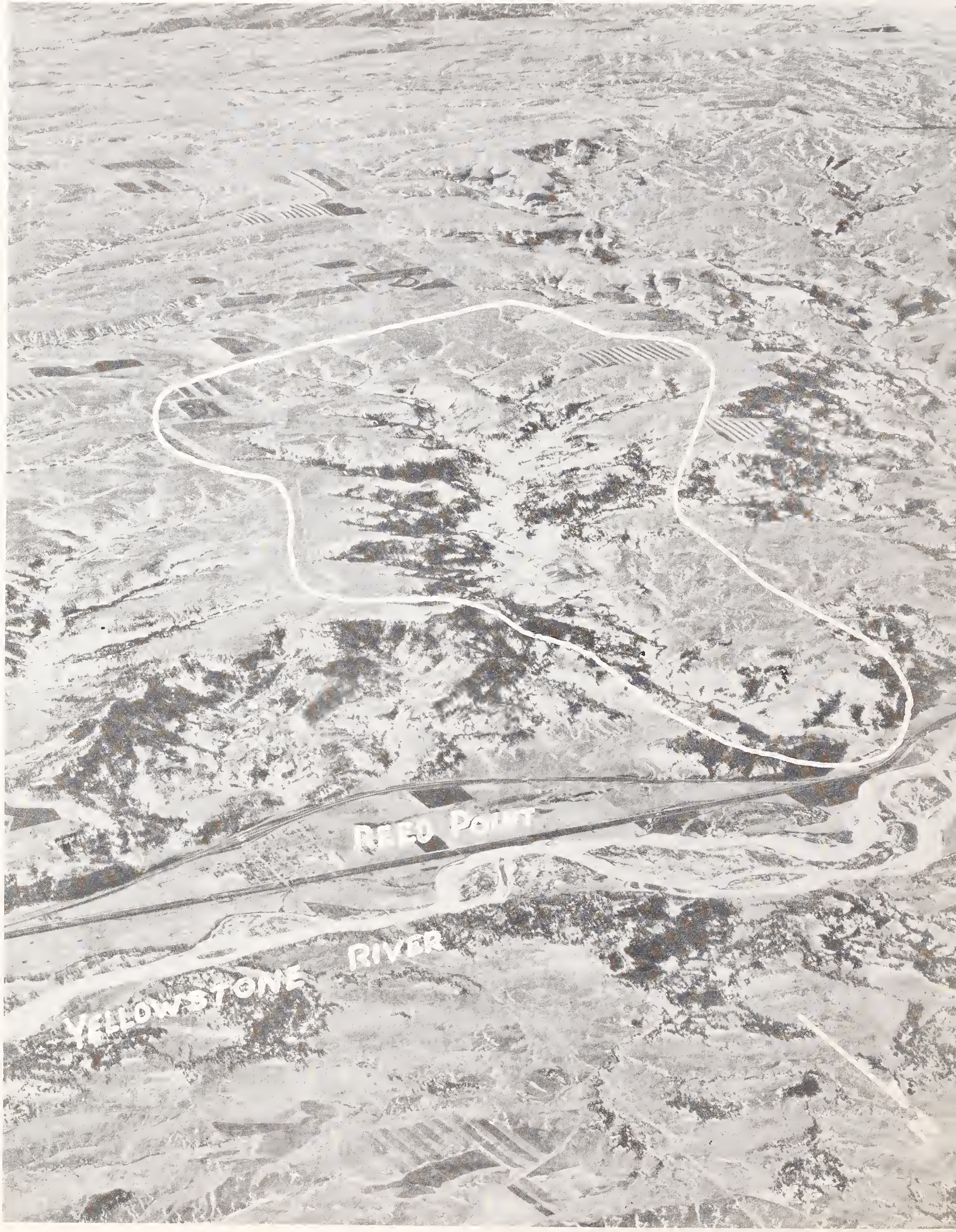


FIGURE B-5: Hump Creek, looking South

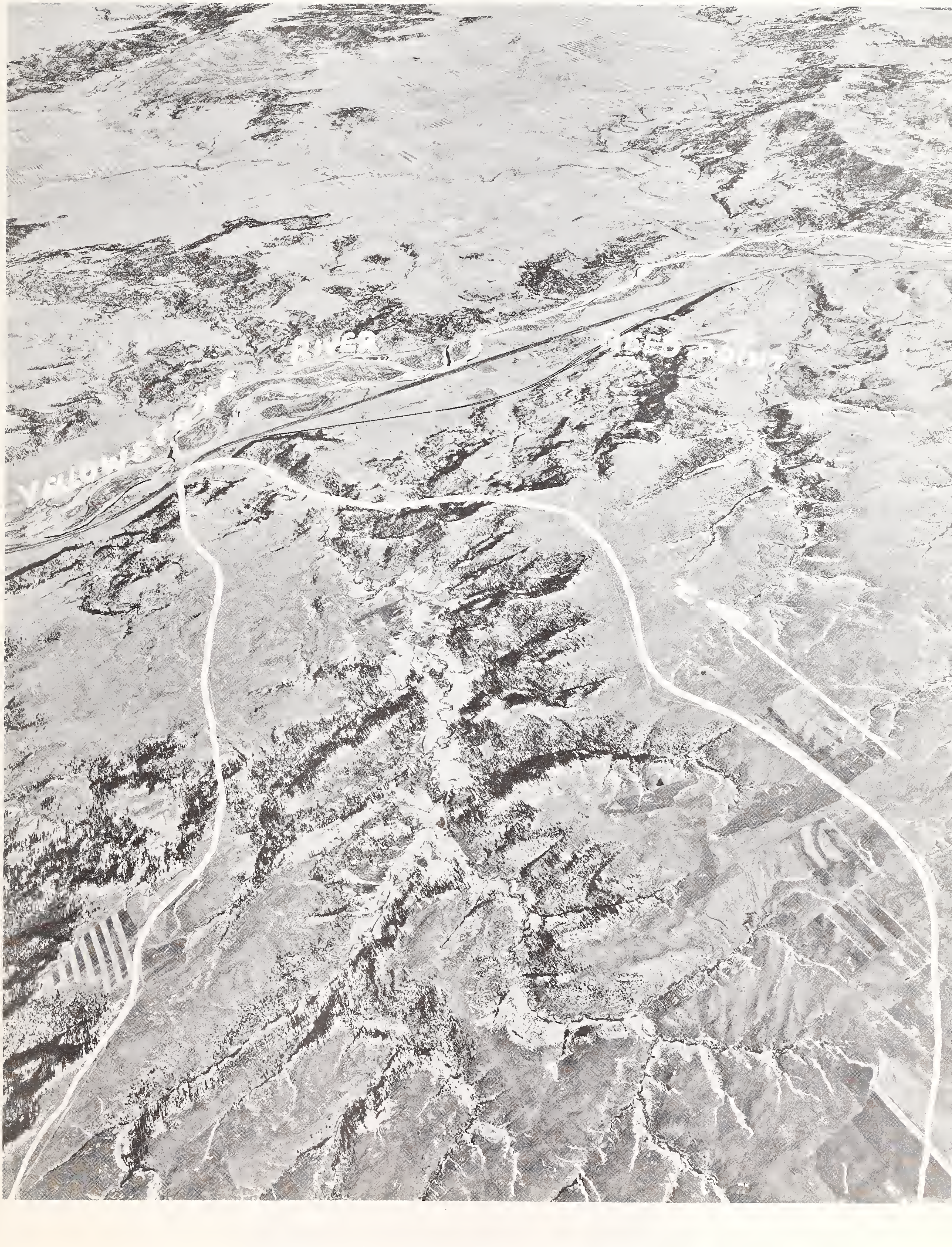


FIGURE B-6: Hump Creek, looking North

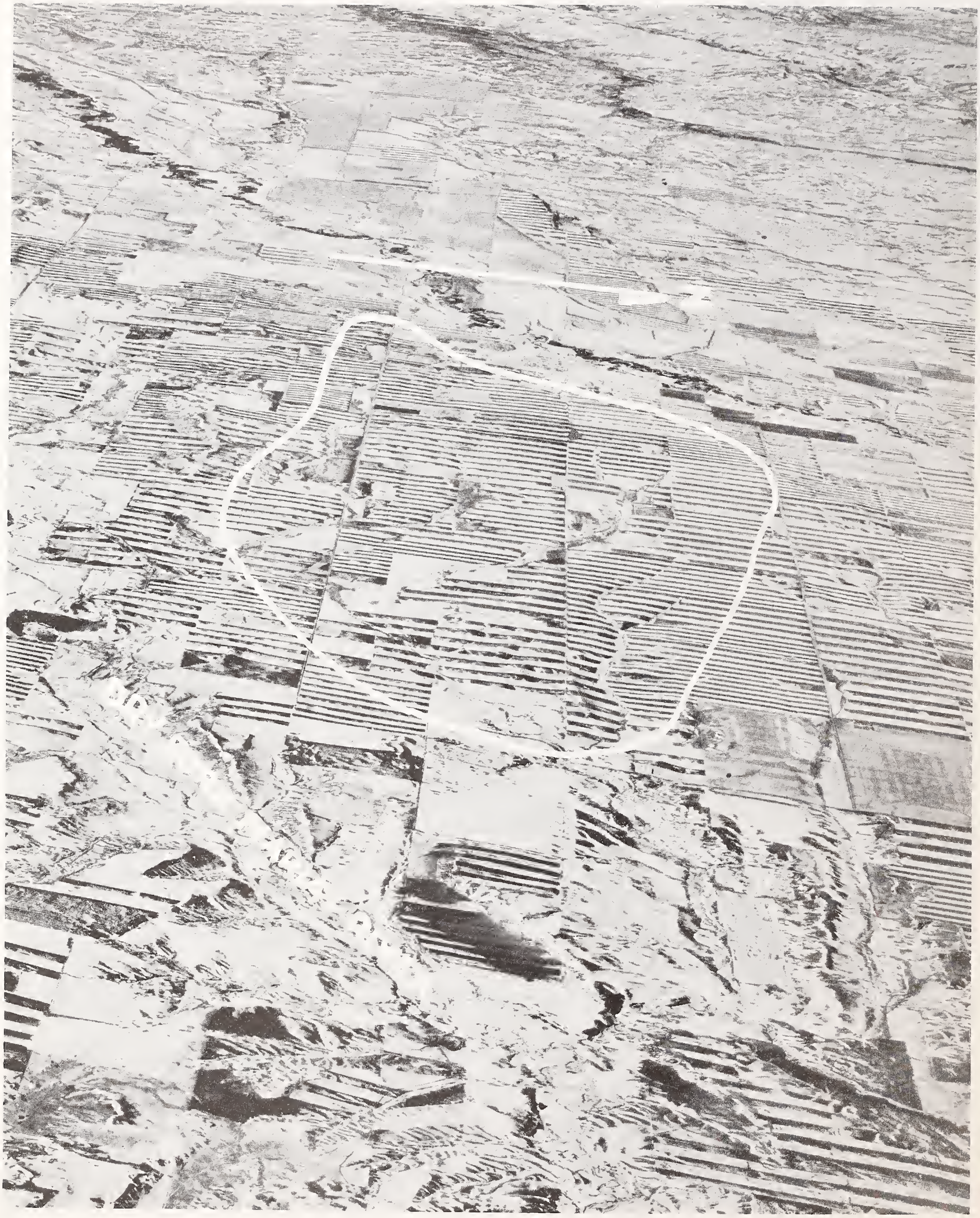


FIGURE B-7: Lone Man Coulee, looking West

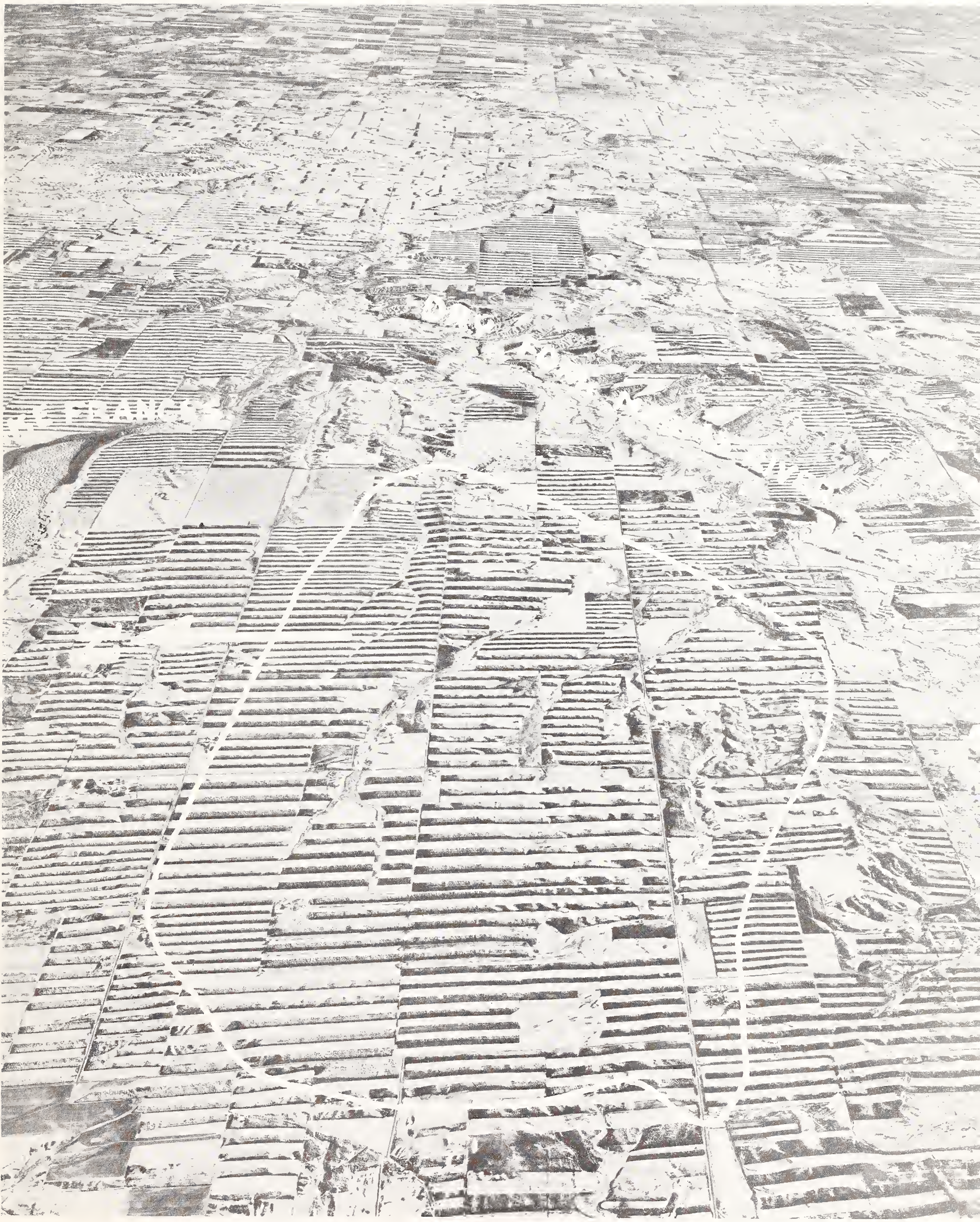


FIGURE B-8: Lone Man Coulee, looking East

APPENDIX C

Watershed Characteristics

a. Area
b. Shape
c. Compactness Coefficient
d. Orientation
e. Elevation
f. Stream Channel Length
g. Stream Channel Slope
h. Overland Slope
i. Number of Streams
j. Drainage Density
k. Stream Density
l. Land Use
m. Infiltration Index
n. Ponds

WATERSHED CHARACTERISTICS

	BACON CREEK	DUCK CREEK	EAST FORK DUCK CREEK	HUMP CREEK	LONE MAN COULEE
AREA, square miles	21.2*	54.0*	12.4*		14.1*
* denotes area as reported by U.S.G.S.	18.0	53.8	13.7	7.6	14.6
SHAPE $\frac{\text{Longest Straight Line}}{\text{Longest Perpendicular}}$	4.332	2.721	3.684	2.569	2.448
COMPACTNESS COEFFICIENT $\frac{\text{Perimeter of Watershed}}{\text{Circumference of Circle of area equal to watershed area}}$	1.48	1.28		1.59	1.28
ORIENTATION Az = Stream Azimuth (from mouth) Li = Length of stream segment $\frac{\Sigma(\text{Az Li})}{\Sigma \text{ Li}}$	289	164	138	177	258
ELEVATION, feet — At gaging sta.	4208	2607	2714	3775	3775
At watershed divide	5000	3625	3320	4762	4140
Mean	4578	2853	2862	4144	3916
(Mean elevation is mean of elevations at 0.8L and 0.2L)					
STREAM CHANNEL LENGTH, Miles — L	12.90	23.61	13.05	6.44	8.45
Lca	6.00	10.00		4.05	4.55
L = length to end of blue line on USGS maps.					
Lca = length to point nearest centroid of area.					

WATERSHED CHARACTERISTICS (Continued)

		BACON CREEK	DUCK CREEK	EAST FORK DUCK CREEK	HUMP CREEK	LONE MAN COULEE
STREAM CHANNEL SLOPE		.011821	.005956	.006920	.024124	.006390
OVERLAND SLOPE	$\frac{\text{Length from end of blue-line stream to divide}}{\text{Elevation}}$	.0162	.0596	.0763	.0650	.0194
NO. OF STREAMS	Order # 1	364	556	159	138	56
	# 2	92	157	44	35	15
	# 3	19	32	10	8	5
	# 4	3	8	2	2	1
	# 5	1	2	1	1	
	# 6		1			
DRAINAGE DENSITY	$\frac{\text{Total Miles of Streams}}{\text{Square Miles}}$	1.37	1.04		2.14	1.13
STREAM DENSITY	Total Number	479	756	216	184	77
	Number per sq. mile	26.661	14.054	15.803	24.179	5.461
LAND USE (Average 1964, 65, 66)	% Grain &/or Grass	98.7	90.5	91.3	74.2	57.4
	% Summer Fallow or bare	1.3	9.5	8.7	1.7	42.6
	% Timber				24.1	
INFILTRATION INDEX	$\frac{\sum(\text{Ave. Infiltrometer rate x area})}{\sum \text{Area}}$	.08824	.10022	.09689	.10155	.09481
PONDS	Number	10	10	2	0	7
	Total Area (sq.mi.)	.01569	.02922	.00632	0	.02049

APPENDIX D

SOIL CHARACTERISTICS

a. Grain Size Analysis
b. Atterberg Limits
c. Soil Survey Data
d. Water Intake Rates

SUMMARY SOILS DATA
GRAIN SIZE ANALYSIS AND ATTERBERG LIMITS

STATION (Soil Name)	DEPTH	PERCENT FINER THAN								LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
		6mm	2mm	.6mm	.2mm	.06mm	.02mm	.006mm	.002mm			
BACON CREEK												
Lode	3in	95.0	86.0	73.5	62.0	50.5	36.5	25.0	18.0	48.0	36.0	12.0
(Musselshell)	9in	84.0	72.0	54.0	40.0	33.0	26.5	19.5	14.5	47.1	33.1	14.0
	18in	84.0	70.0	52.5	41.0	32.5	26.0	22.0	16.5	41.8	19.4	22.4
Robertson	3in	99.0	96.0	90.0	78.5	64.5	54.5	44.5	35.0	43.2	26.2	17.0
(Crago-Bercail)	9in	88.5	81.0	68.0	54.0	42.5	34.0	26.5	20.5	40.5	29.7	10.8
	18in	91.5	85.0	74.0	60.5	48.0	38.0	28.5	21.0	41.2	24.8	16.4
DUCK CREEK												
Hauk	3in	100.0	99.5	92.5	77.0	54.0	19.5	5.5	4.0	33.5	24.5	9.0
(Macay)	9in	100.0	99.5	89.5	75.5	69.5	50.5	14.0	6.5	31.5	23.5	8.0
	18in											
Jonas	3in	99.5	99.0	98.0	78.0	48.5	27.0	16.0	10.0	*	30.8	
(Pennel)	9in	97.0	92.5	88.5	76.0	55.0	35.5	24.0	16.5	*	23.8	
	18in	94.0	88.0	75.0	59.5	49.0	40.0	30.0	17.5	35.0	23.4	11.6
Jordan	3in	100.0	98.5	85.0	65.5	53.5	39.0	24.0	15.5	40.0	22.6	17.4
(Cherry)	9in	100.0	98.5	85.0	72.0	70.0	45.5	30.5	19.5	36.0	23.1	12.9
	18in	100.0	100.0	99.5	90.5	76.0	60.5	42.0	30.0	30.0	20.3	9.7
HUMP CREEK												
Cain	3in	97.0	91.0	73.0	53.0	42.5	32.4	21.5	16.0	59.2	30.2	29.0
(Absarokee)	9in	82.0	57.0	25.0	14.5	12.5	11.0	8.5	7.0	64.8	32.5	32.3
	18in	98.0	69.5	33.5	24.0	21.5	18.0	16.0	11.0	*	33.1	
LONEMAN COULEE												
Geiger	3in	98.5	97.5	96.0	81.0	59.0	37.5	27.0	19.0	40.8	34.8	6.0
(Kiev)	9in	99.5	98.5	91.5	73.0	55.5	41.0	29.5	22.5	43.6	24.4	19.2
	18in	97.0	96.0	91.0	77.0	62.0	47.0	36.0	26.0	39.4	27.8	11.6
Toren	3in	100.0	99.0	91.0	72.0	54.0	43.0	35.0	26.0	41.3	23.5	17.8
(Kiev)	9in	99.0	98.0	91.0	71.0	49.0	36.0	30.5	22.0	36.7	21.2	15.5
	18in	99.5	97.5	85.0	65.0	50.0	40.0	33.0	27.0	41.5	21.1	20.4

BACON CREEK WATERSHED

SOIL SURVEY DATA

Publication Symbol	Hydrologic Soil Group	Soil Name	Approximate Acres	%
Aa		Alluvial land clay and saline, 2-4% slope	280	1.5
Ab	C	Ashuelot gravelly loam, 0-2% slope	258	1.4
Ac		Ashuelot-Musselshell complex, 0-2% slope	1169	6.3
Ad		Ashuelot-Musselshell complex, 2-4% slope	374	2.0
Ba	C	Bercail clay loam, 1-4% slopes	1207	6.5
Bb		Bercail clay loam, shale substratum, 4-10% slopes	380	2.0
Bc		Bercail-Thebo clays, 4-10% slopes	1000	5.4
Bd		Bercail-Thebo clays, 10-15% slopes	194	1.0
Be		Bercail-Thebo clays, 15-45% slopes	1479	8.0
Bf		Bercail clay loam, saline 4-10% slopes	99	0.5
Ca	B	Crago loam, 1-4% slope	216	1.2
Cb		Crago loam, 4-8% slope	89	0.5
Cd		Crago cobbly loam, 8-15% slope	441	2.4
Ce		Crago-Bercail complex, 15-45% slope	3099	16.5
Ma	B	Musselshell gravelly loam, 0-2% slope	2366	12.6
Mb		Musselshell gravelly loam, 2-4% slope	989	5.3
Mc		Musselshell gravelly loam, 4-8% slope	872	4.7
Md		Musselshell gravelly loam, 8-15% slope	116	0.6
Me		Musselshell-Crago complex, 0-2% slope	2616	14.0
Mf		Musselshell-Crago complex, 2-8% slope	754	4.0
Mg		Musselshell-Crago complex, 8-15% slope	178	1.0
Ta	D	Thebo clay, 4-20% slopes	488	2.6
		Total Acres	18664	100.0

DUCK CREEK

SOIL SURVEY DATA

ication mbol	Hydrologic Soil Group	Soil Name	Approximate Acres	%
Aa	B	Alluvial land, loamy 0 to 4% slopes	1337	3.85
Ba	B	Briley loam, 2 to 4% slopes	9	0.03
Bb	B	Briley gravelly loam, 2 to 4% slopes	33	0.10
Bc	B	Brockway silty clay loam, 0 to 2% slopes	275	0.79
Bd	B	Brockway silty clay loam, 2 to 4% slopes	45	0.13
Ca	B	Cherry silty clay loam, 0 to 2% slopes	1240	3.57
Cb	B	Cherry silty clay loam, 2 to 4% slopes	87	0.25
Cc	B	Cherry silt loam, 0 to 2% slopes	45	0.13
Cd	B	Cherry silty loam, 2 to 4% slopes	267	0.77
Ce	B	Chinook fine sandy loam, 1 to 6% slopes	146	0.42
Cg	C	Cabba complex, 15 to 40% slopes	2720	7.83
Ch	B/C	Cabba-Brandenburg complex, 8 to 45% slopes	70	0.20
Ci	B/C	Cabba-McGuire complex, 4 to 8% slopes	165	0.48
Cj	B/C	Cabba-McGuire complex, 8 to 20% slopes	405	1.17
Ck	B	Cabba-Pennel loams, 8 to 20% slopes	3724	10.72
Cl	C/D	Cabba-shale outcrop complex, 15% plus slopes	4054	11.67
Fa	B	Farnuf loam, 0 to 2% slopes	813	2.34
Fb	B	Farnuf loam, 2 to 4% slopes	591	1.70
Ha	B	Harkan gravelly loam, 6 to 35% slopes	414	1.19
Hb	B/C	Harkan-Cabba complex, 15 to 40% slopes	880	2.53
Hc	B/C	Harkan and Cabba soils, 6 to 15% slopes	1380	3.97
La	C	Lambert and Lothair soils, 15% and steeper slopes	590	1.70
Ma	A	McGuire fine sandy loam, 4 to 8% slopes	101	0.29
Mb	A	McGuire fine sandy loam, 8 to 20% slopes	1573	4.53
Mc	A	McGuire loamy fine sand, 4 to 20% slopes	322	0.93
Md	B	Macay loam, 0 to 2% slopes	1659	4.78
Me	B	Macay loam, 2 to 4% slopes	318	0.92
Pa	B	Pennel-Macay loams, 2 to 4% slopes	96	0.28
Pb	B	Pennel-Macay loams, 4 to 8% slopes	1624	4.68
Pc	B	Pennel-Cabba loams, 4 to 8% slopes	7154	20.60
Ra	B	Remuda fine sandy loam, 2 to 8% slopes	698	2.01
Rb	B	Remuda-McGuire complex, 4 to 8% slopes	1620	4.67
Rc	B	Romine fine sandy loam, 0 to 2% slopes	70	0.20
Ya	B/C	Yawdim-Cabba soils 4 to 35% slopes	199	0.57
		Total	34,724	100.00

HUMP CREEK WATERSHED

SOIL SURVEY DATA

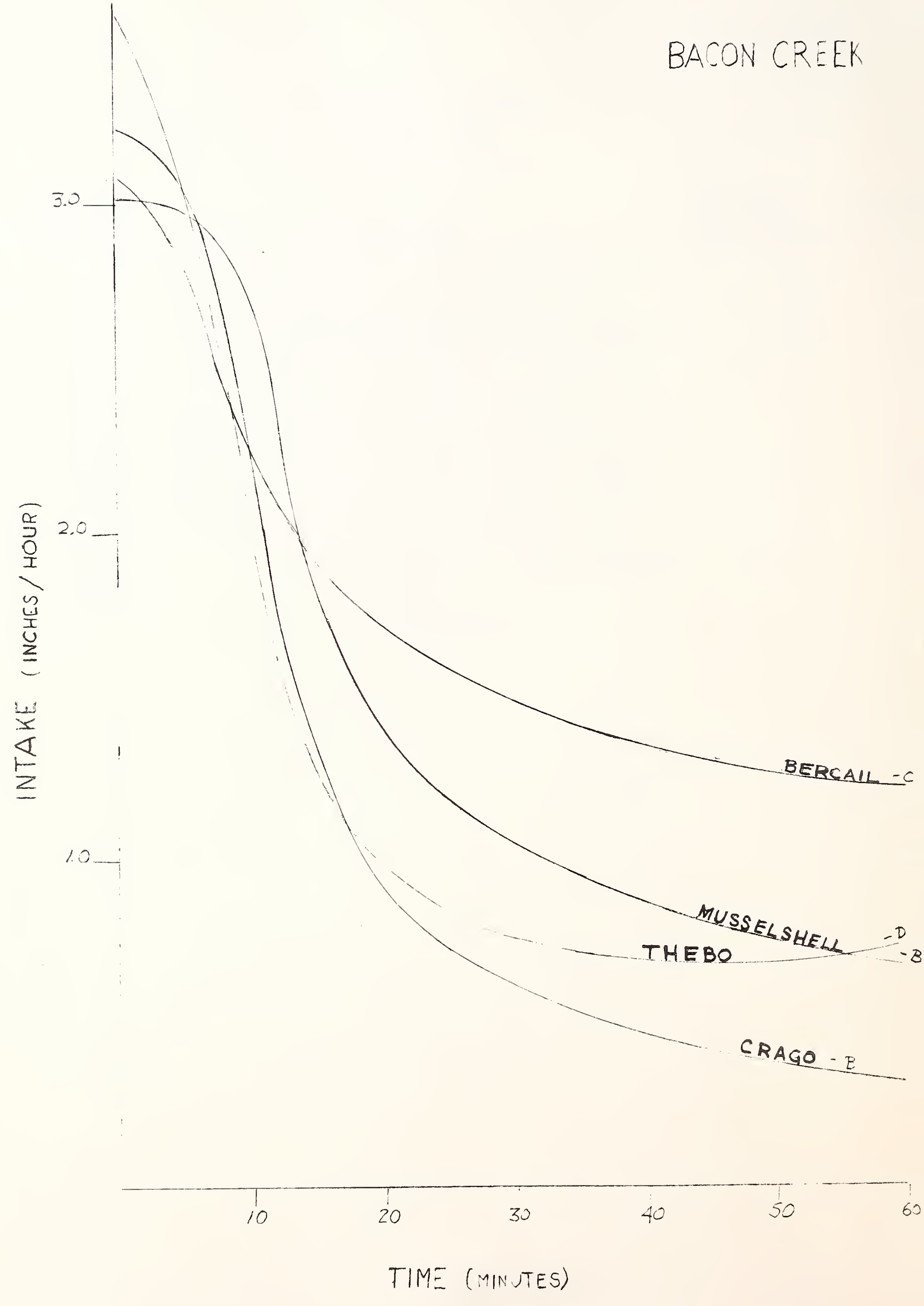
Publication Symbol	Hydrologic Soil Group	Soil Name	Approximate Acres	%
Aa	C	Absarokee-Amherst, 2-8 per cent slope	259	5.8
Ab		Absarokee-Amherst, 8-20 per cent slope	132	2.9
Ac		Absarokee-Amherst, stony clay loam 4-8% slope	348	7.8
Ad	C	Amherst-Castner, stony loams 8-15% slope	720	16.1
Ba	C	Basket clay loam complex, 2-8% slope	118	2.6
Bb	C/D	Beaudry-Absarokee complex 4-8% slope	60	1.3
Ae	C	Absarokee clay loam, clay substratum 4-8% slope	19	0.4
Ma	C/D	Midway-Castner association, 4-10% slope	640	14.3
Mb	C/D	Midway-Castner association, 10-30% slope	509	11.3
Mc	D	Midway-Rock outcrop complex, 15-50% slope	1565	35.0
Wa	C	Work clay loam, 4-8% slope	71	1.6
Wb		Work clay loam, 8-16% slope	39	0.9
		Total acres	4480	100.0

LONEMAN COULEE WATERSHED

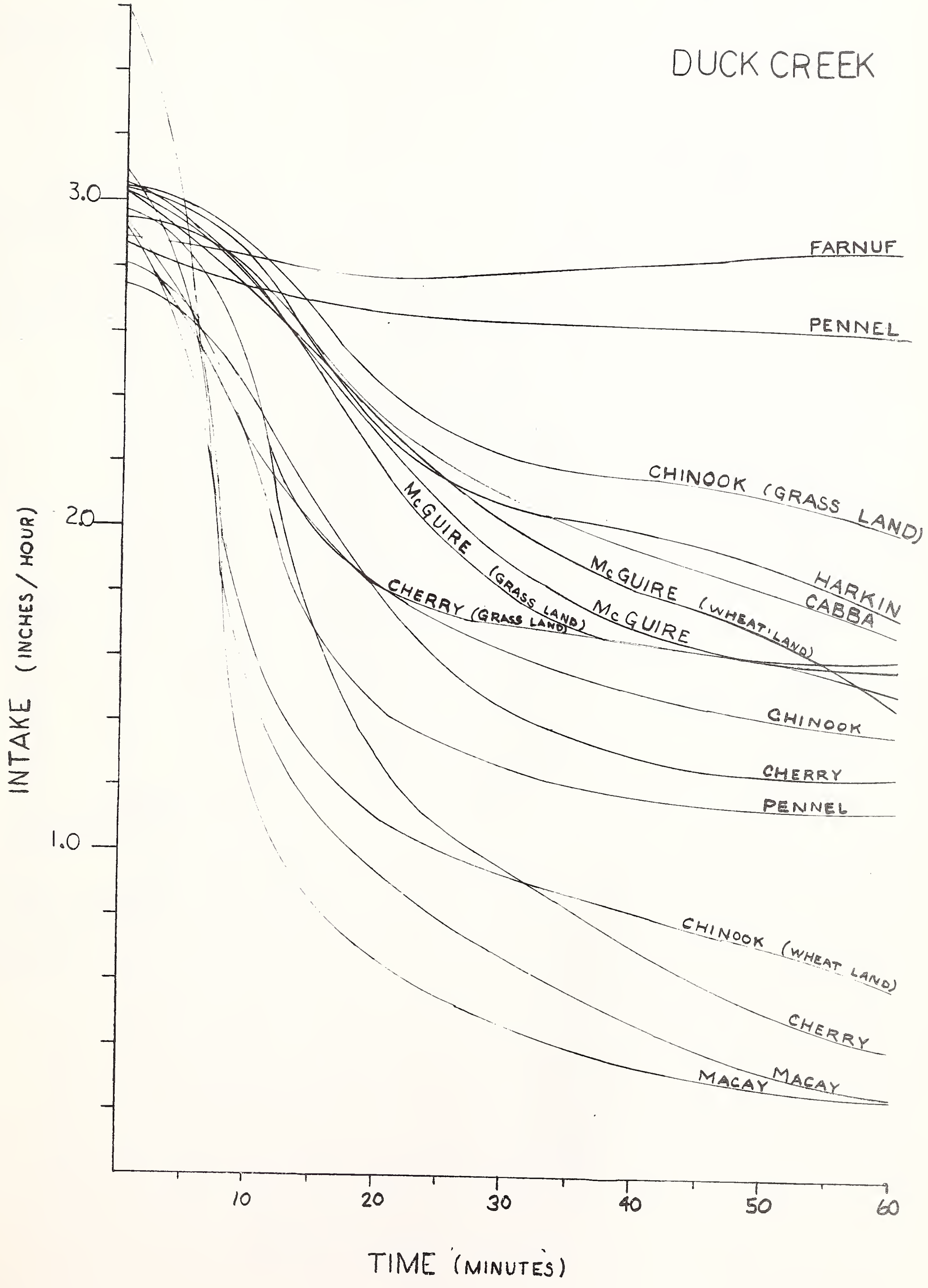
SOIL SURVEY DATA

blication Symbol	Hydrologic Soil Group	Soil Name	Approximate Acres	%
Aa		Alluvial land, poorly drained and saline, 0 to 4% slopes	680	7.3
Ca	C	Cabba loam and clay loam, 8-20% slopes	281	3.0
Cb		Cabba loam-Rockland complex, 15-40% slopes	107	1.1
Ka	B	Kiev loam, 0 to 2% slopes	2283	24.4
Kb		Kiev loam, 2 to 4% slopes	1498	16.0
Kc		Kiev loam, 4 to 8% slopes	2323	24.8
Kd		Kiev loam and gravelly loam, 8-15% slopes	851	9.1
La	D	Landusky silty clay, 1 to 4% slopes	295	3.2
Ma	C	Midnight clay loam, 2 to 4% slopes	87	0.9
Mb		Midnight loam, 4 to 10% slopes	344	3.7
Sa		Seeped footslopes, drains and basins, 0-4% slopes	143	1.5
Ua	A/C	Utica-Cabba complex, 8-35% slopes	428	4.6
		Unclassified	38	0.4
		TOTAL WATERSHED AREA	9358	100.0

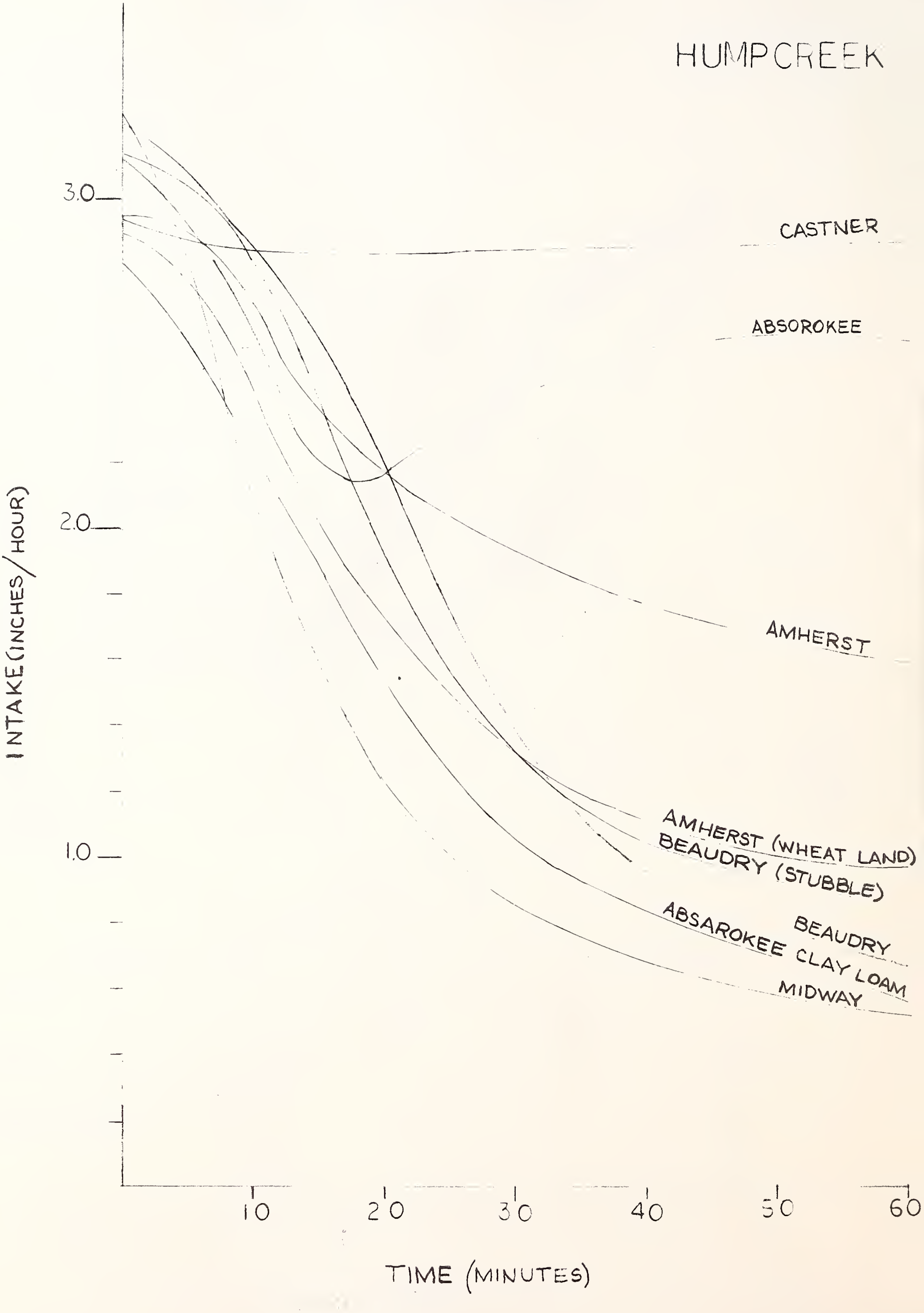
WATER INTAKE RATES



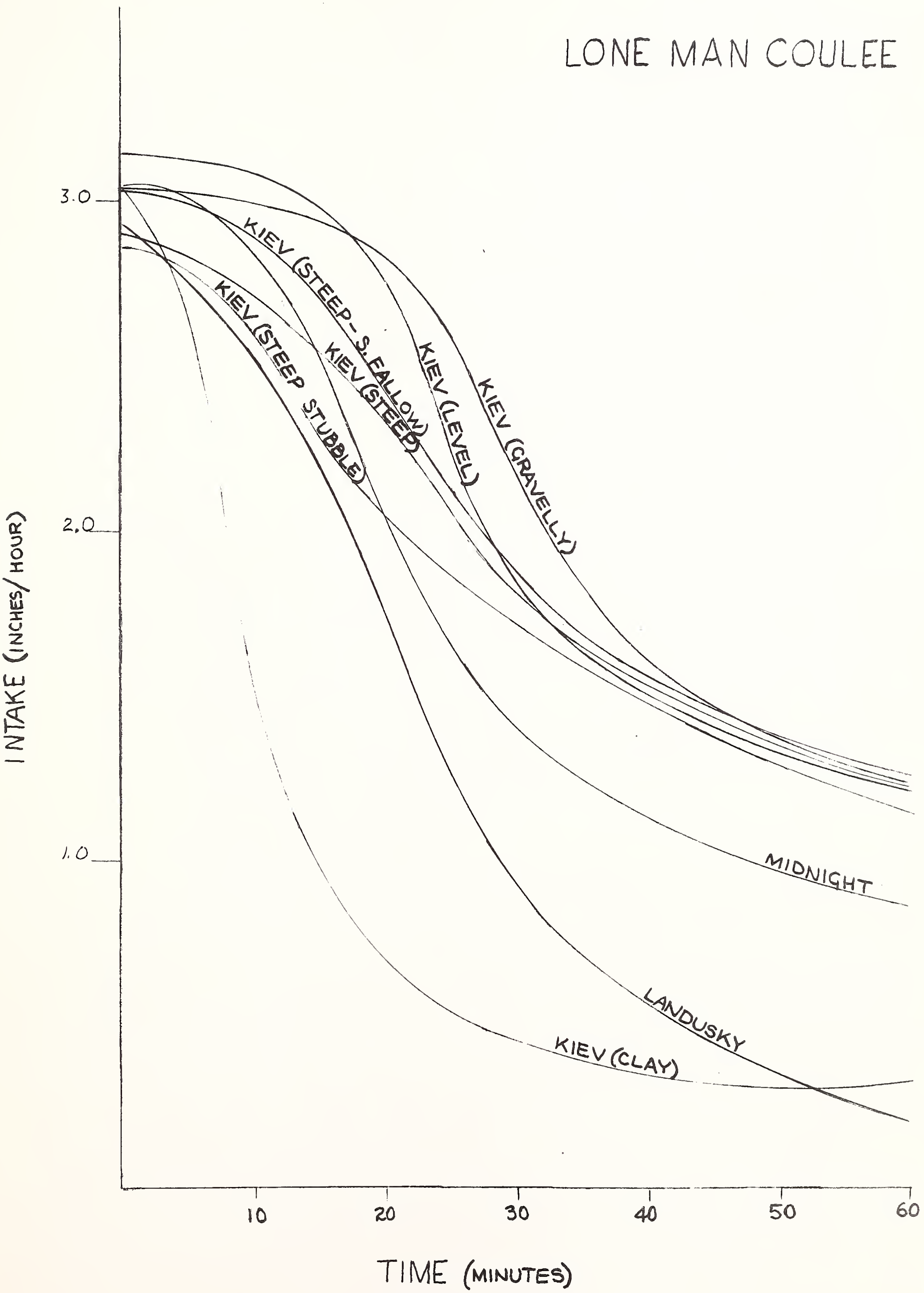
WATER INTAKE RATES



WATER INTAKE RATES



WATER INTAKE RATES



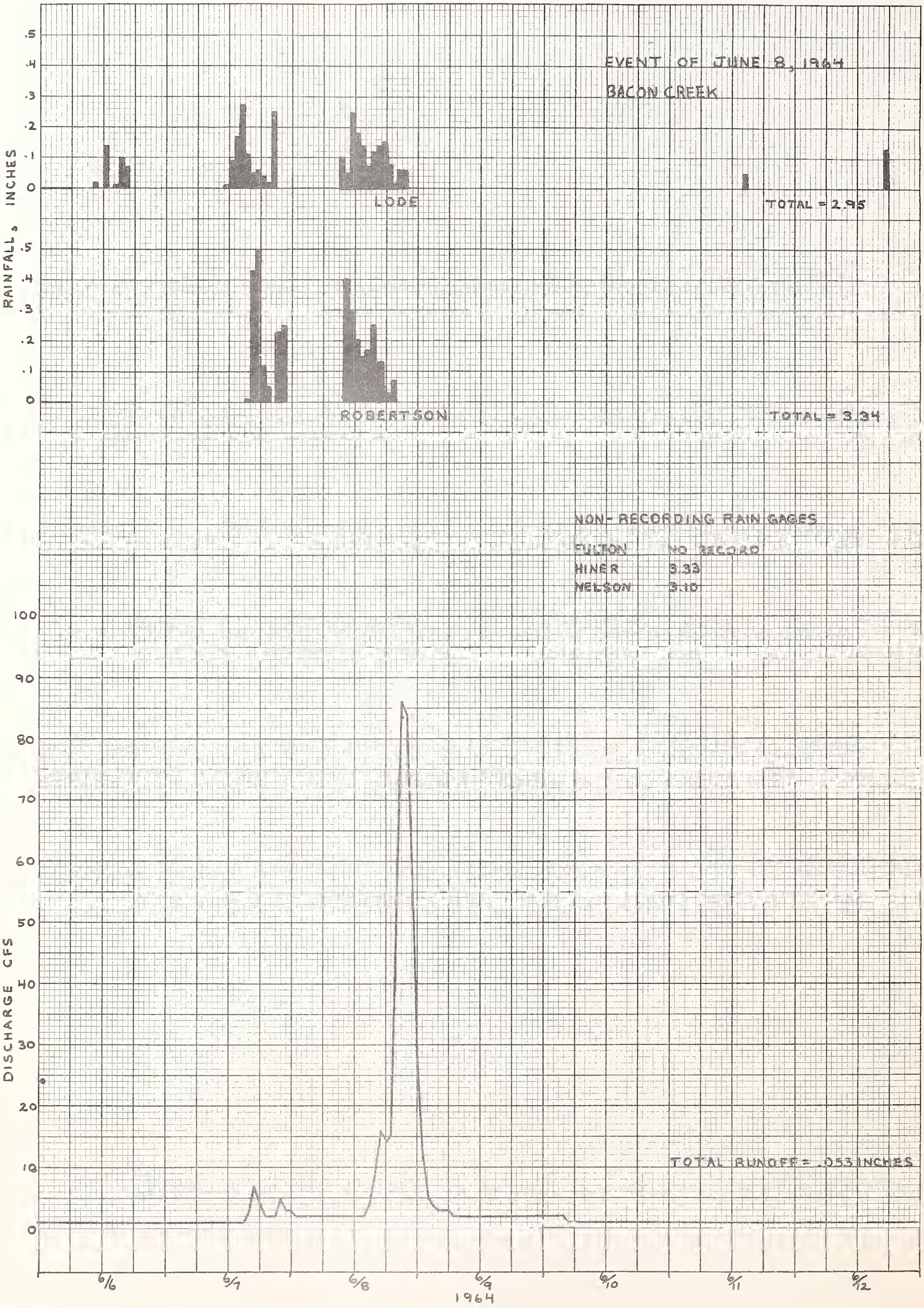
APPENDIX E

HYDROLOGIC DATA

a. Hydrographs
b. Antecedent Meteorological Conditions
c. Monthly Precipitation Totals
d. Snow Survey Measurements

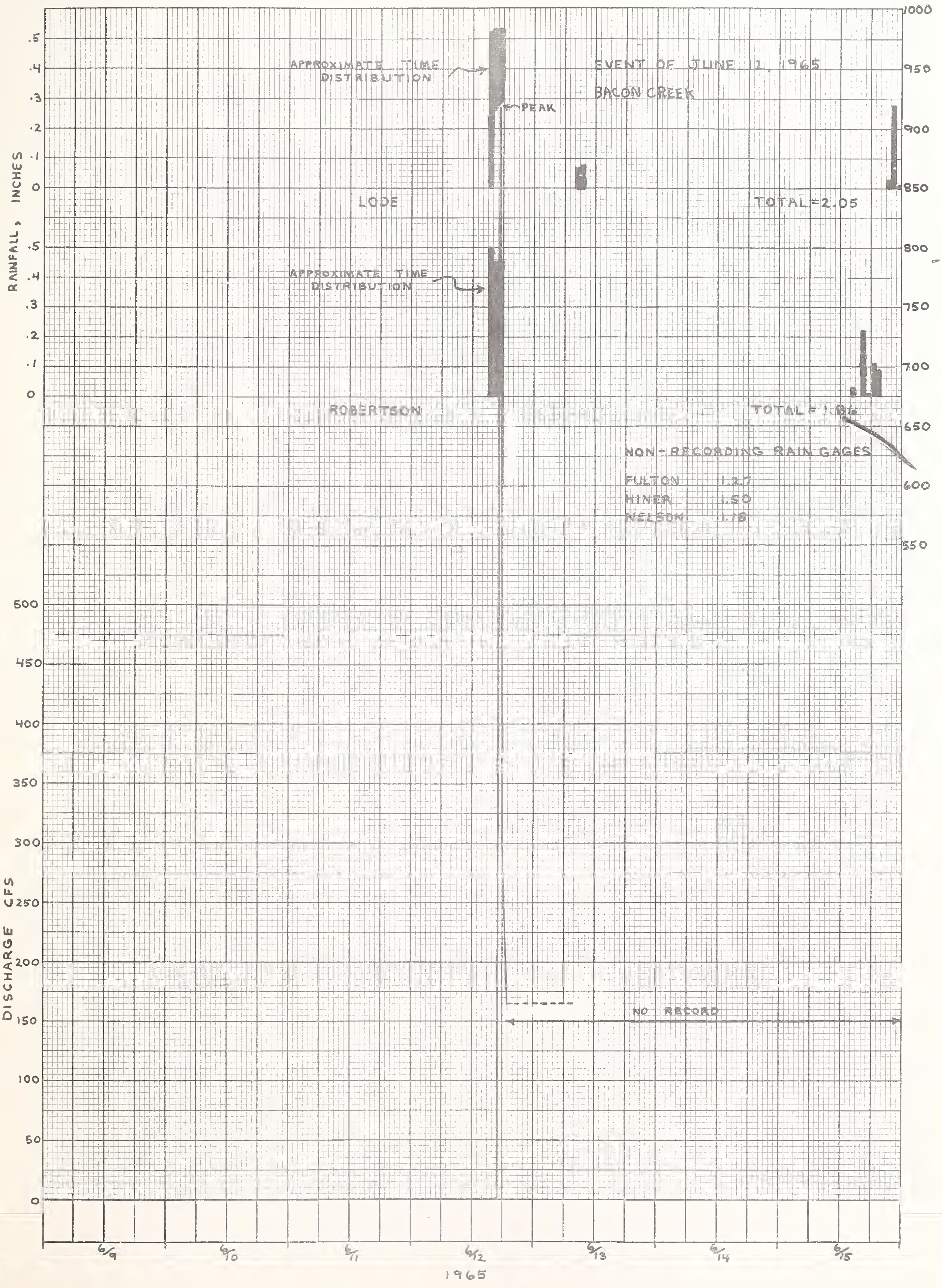
PEAK DISCHARGES RECORDED AT PROJECT WATERSHEDS BY DRAINAGE CORRELATION RESEARCH PROJECT -- 1963-1970
(10 cfs or greater)
Hydrographs follow on successive pages for all these events except those marked *

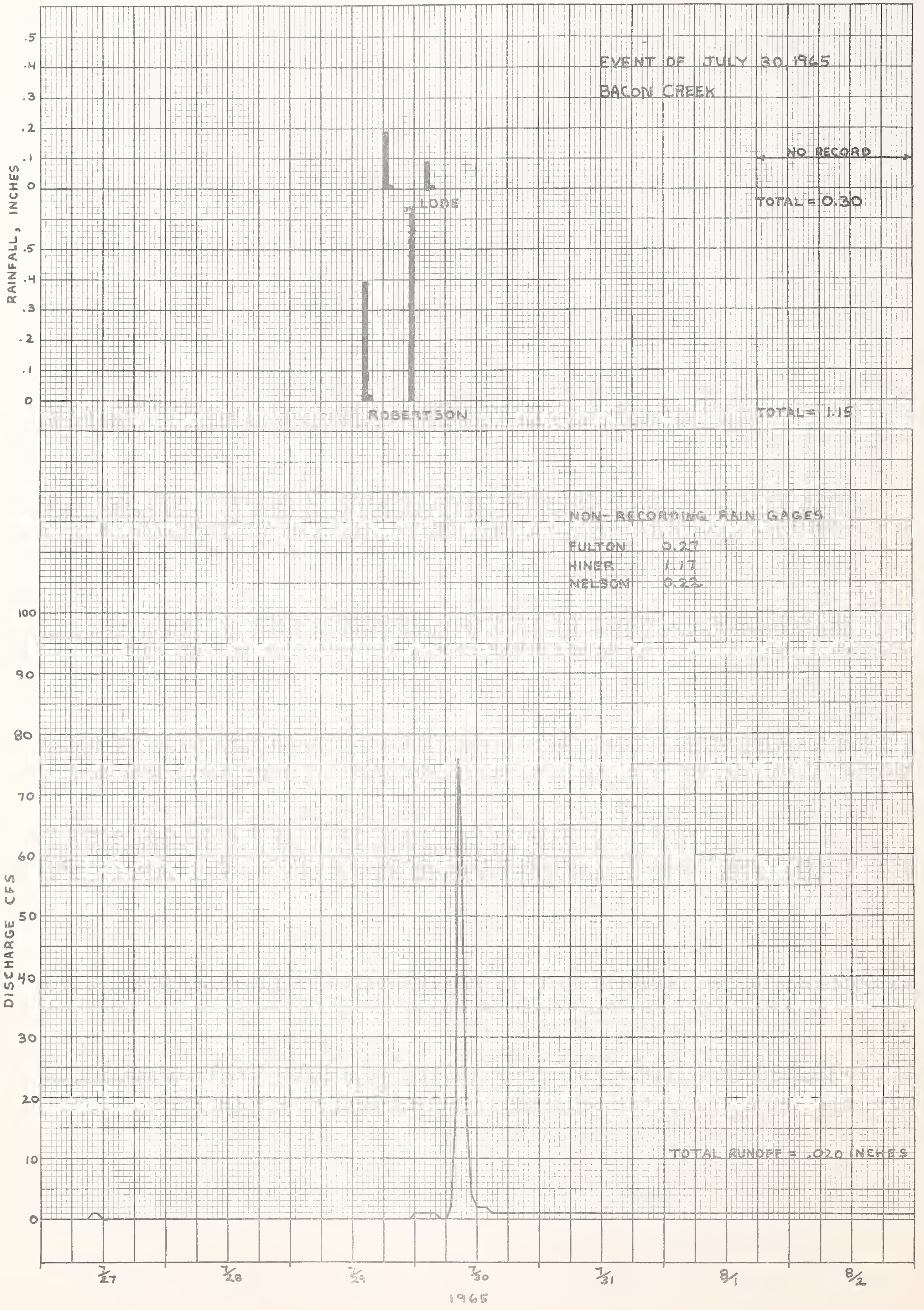
	BACON CREEK	DUCK CREEK	E.FORK DUCK CREEK	HUMP CREEK	LONE MAN COULEE
1.	Jun 8, 64 88 cfs	Jun 20, 64 23 cfs	Jun 19, 64 45 cfs	Mar 24, 67* 8.2	Mar 30, 64 55 cfs
2.	Jun 12, 65 920	Jul 6, 64 78	Jul 5, 64 84	Jun 14, 67 84	May 3, 64 195
3.	Jul 30, 65 76	May 8, 65 18	Mar 30, 65 72	Jun 27, 67 77	Jun 8, 64 1740
4.	Jun 13, 67 59	Jun 16, 65 342	May 8, 65 10	Jul 14, 67* 9.5	Jun 17, 64* 26
5.	Jun 8, 68 52	Jun 30, 65 26	Jun 16, 65 205	Jun 9, 68 110	Feb 17, 65 390
6.	Jun 29, 68* 10.0	Jul 6, 65 61	Jul 5, 65 16	Mar 17, 69 35.5	Feb 27, 65 29
7.	Sep 20, 68* 10.4	Jul 13, 65 150	Jul 12, 65 100		Apr 1, 65 73
8.	Mar 18, 69 67	Mar 13, 66 42	Aug 6, 65 10		Apr 6, 65 240
9.	Mar 27, 69 13	Jul 1, 66 170	Aug 29, 65* 18		Apr 12, 65 18
10.	Mar 31, 69* 24.5	Feb 29, 68 36	Mar 10, 66 65		Apr 17, 65 32
11.	Apr 7, 69* 19.9	Mar 18, 69 185	Jul 1, 66 198		Jun 17, 65 112
12.	Jun 25, 69 10.4	Apr 27, 69 12.9	Mar 10, 67* 32		Jun 25, 65 200
13.	Jul 14, 69* 11.2	Jul 8, 69 36.3	Mar 22, 67* 27		Jul 12, 65 44
14.		Jun 16, 70 19	Feb 27, 68* 35		Feb 23, 66 20
15.			Mar 17, 69 209		Mar 9, 66 150
16.			Apr 26, 69 19.7		Jul 14, 66 53
17.			Jul 7, 69 59		Feb 7, 67 13
18.			Jul 27, 69 17.2		May 7, 67 111
19.					May 14, 67 49
20.					May 30, 67 18
21.					Jun 10, 67 143
22.					Jun 12, 67 36
23.					Jan 23, 68 39
24.					Feb 28, 68* 10
25.					Jun 7, 68* 10.5
26.					Sep 22, 68 32.6
27.					Mar 20, 69 280
28.					Mar 25, 69 129
29.					Mar 31, 69 25.2
30.					Jun 26, 69 27.2

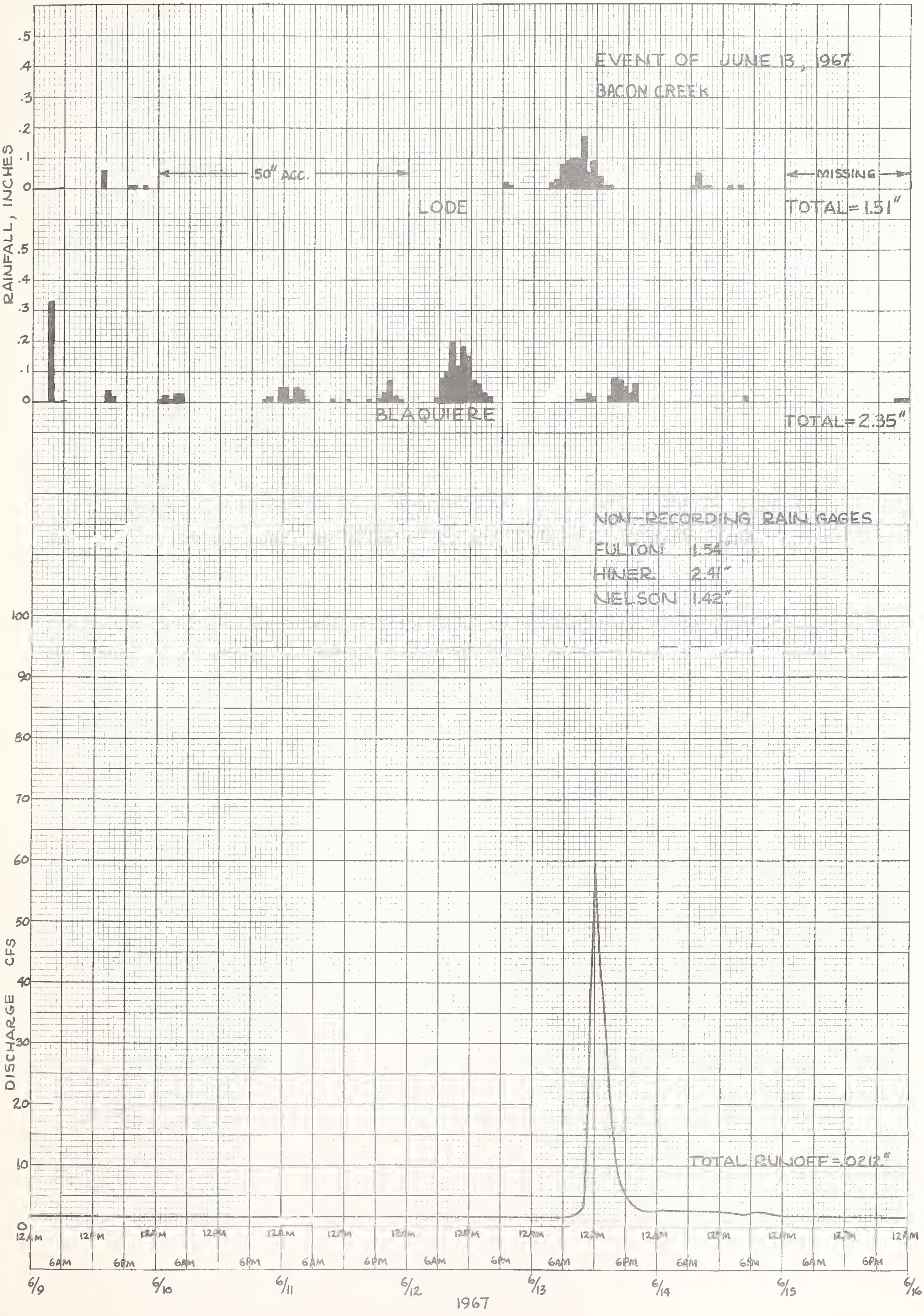


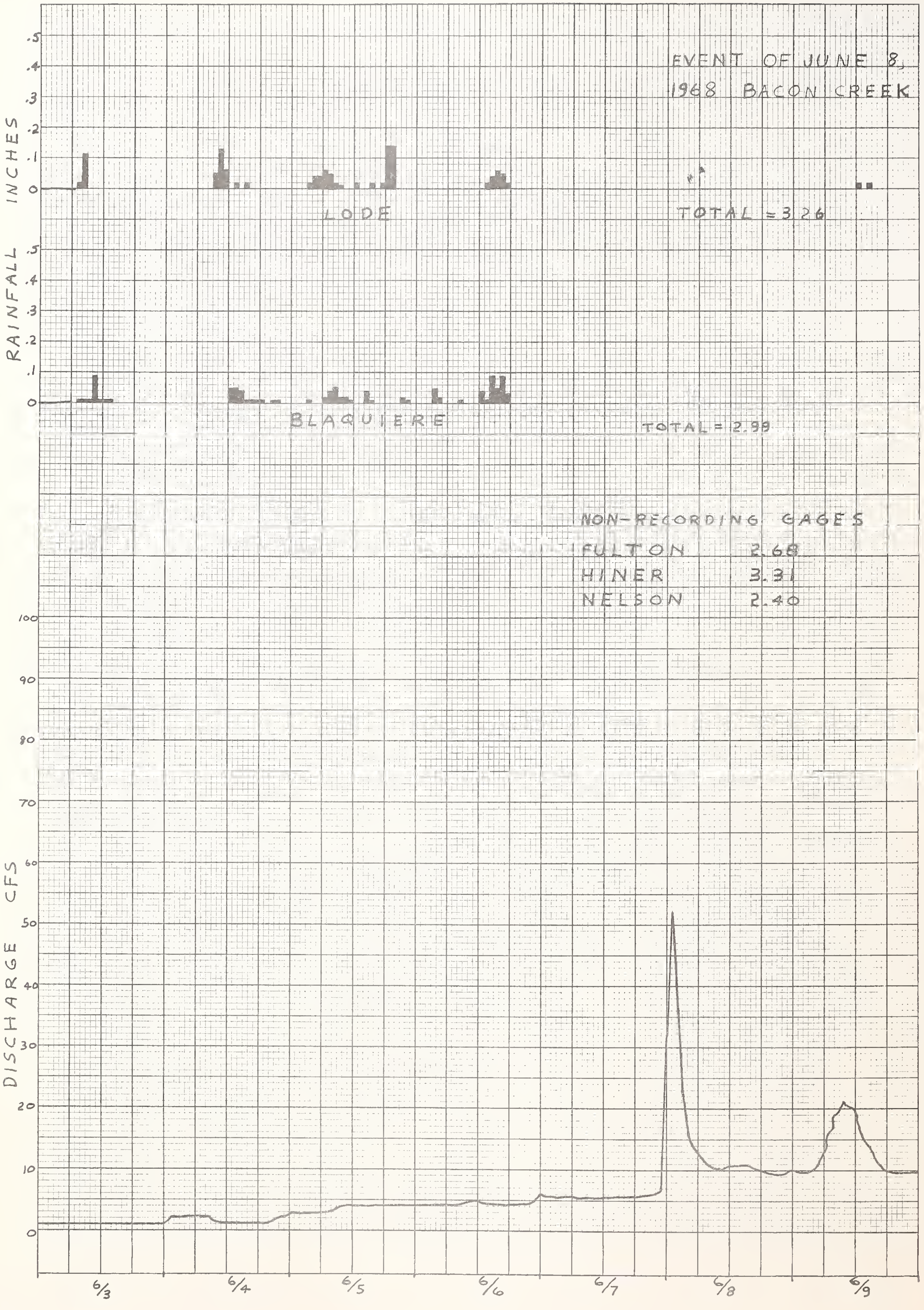
EVENT OF JUNE 8, 1964

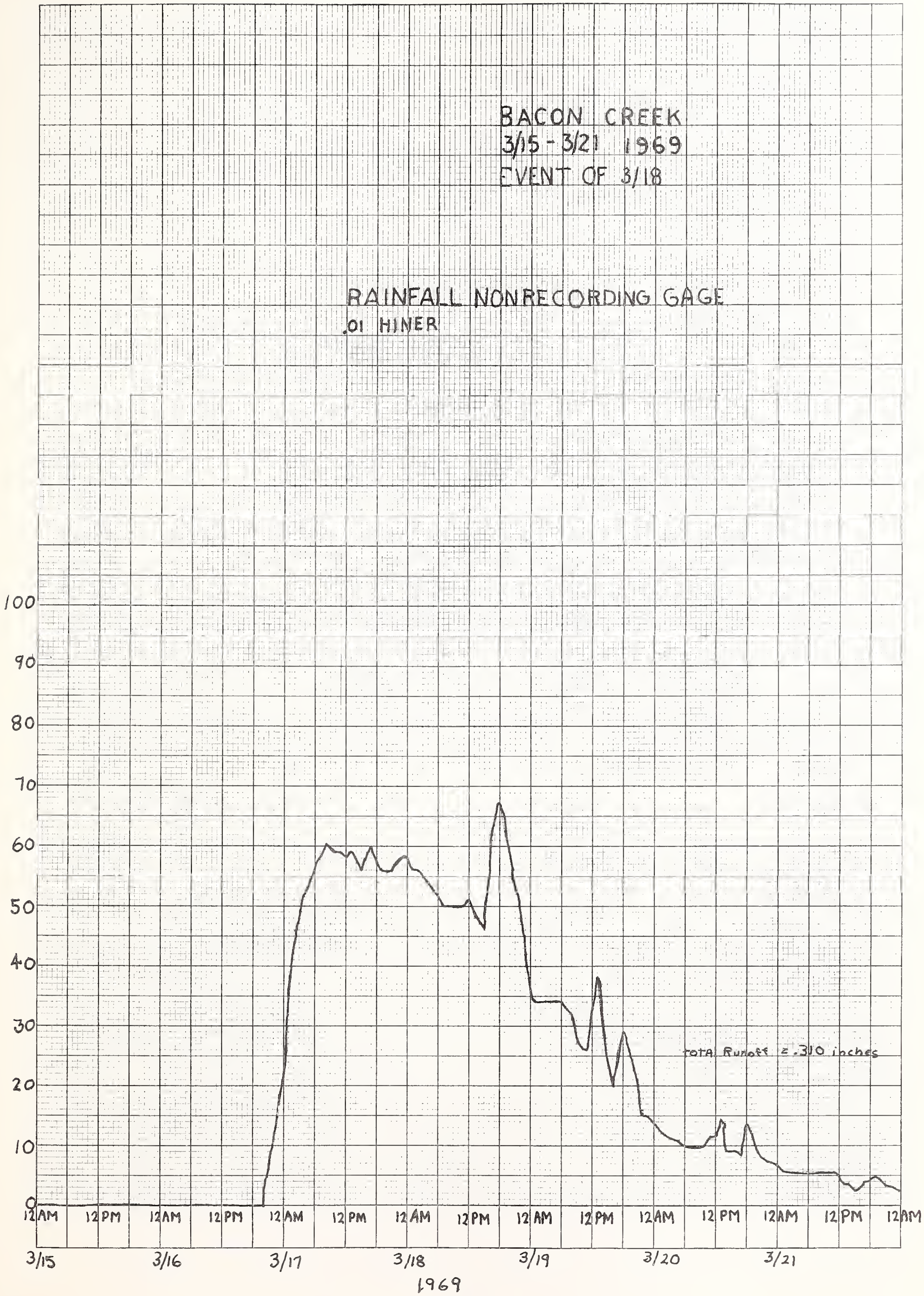
BACON CREEK

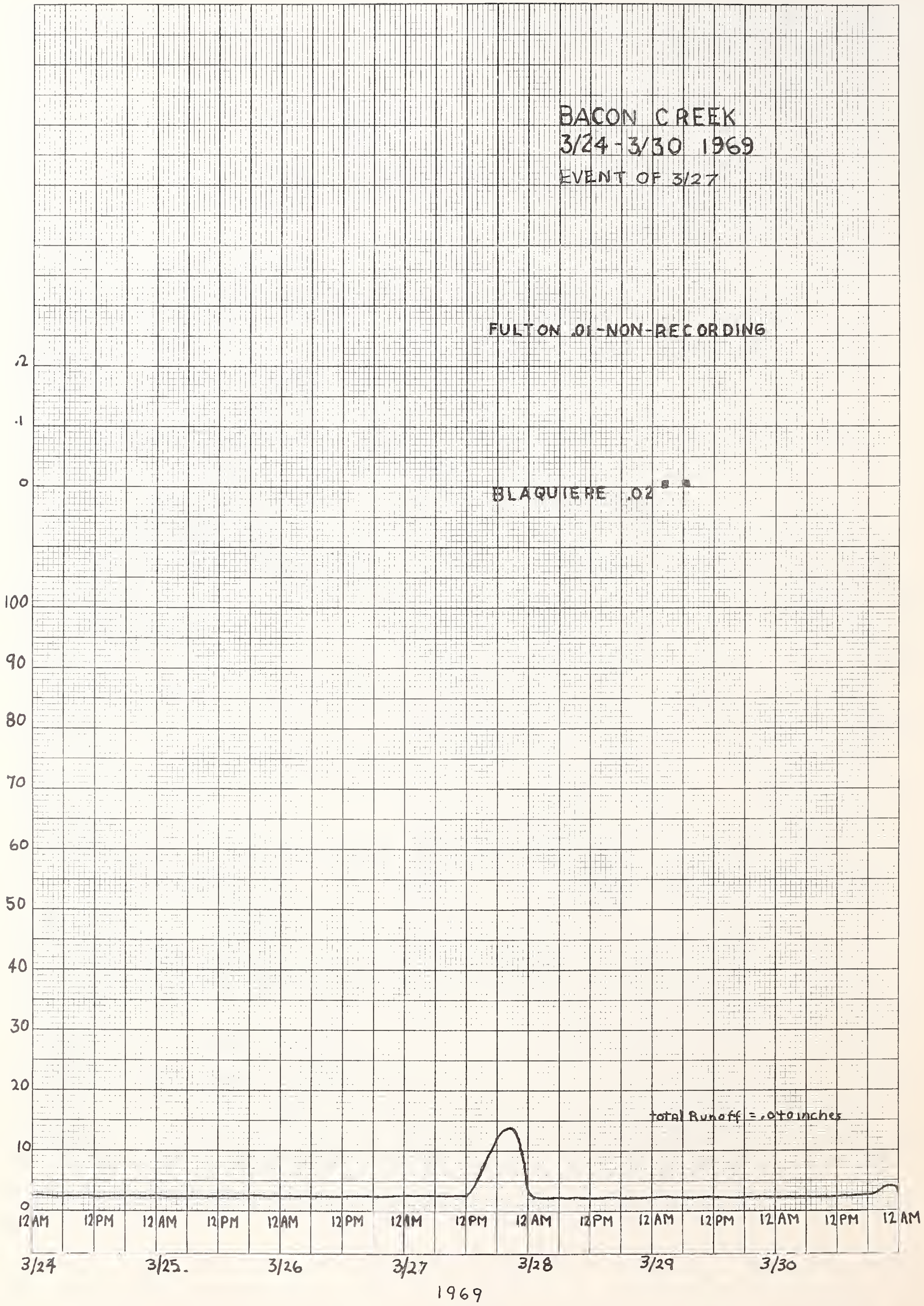

EVENT OF JUNE 12, 1965
BACON CREEK
APPROXIMATE TIME DISTRIBUTION
PEAK
LODE
TOTAL = 2.05
APPROXIMATE TIME DISTRIBUTION
ROBERTSON
TOTAL = 1.86
NON-RECORDING RAIN GAGES
FULTON 1.27
HINER 1.50
NELSON 1.18
NO RECORD
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
DISCHARGE CFS
500
450
400
350
300
250
200
150
100
50
0
1000
950
900
850
800
750
700
650
600
550
6/9
6/10
6/11
6/12
6/13
6/14
6/15
1965

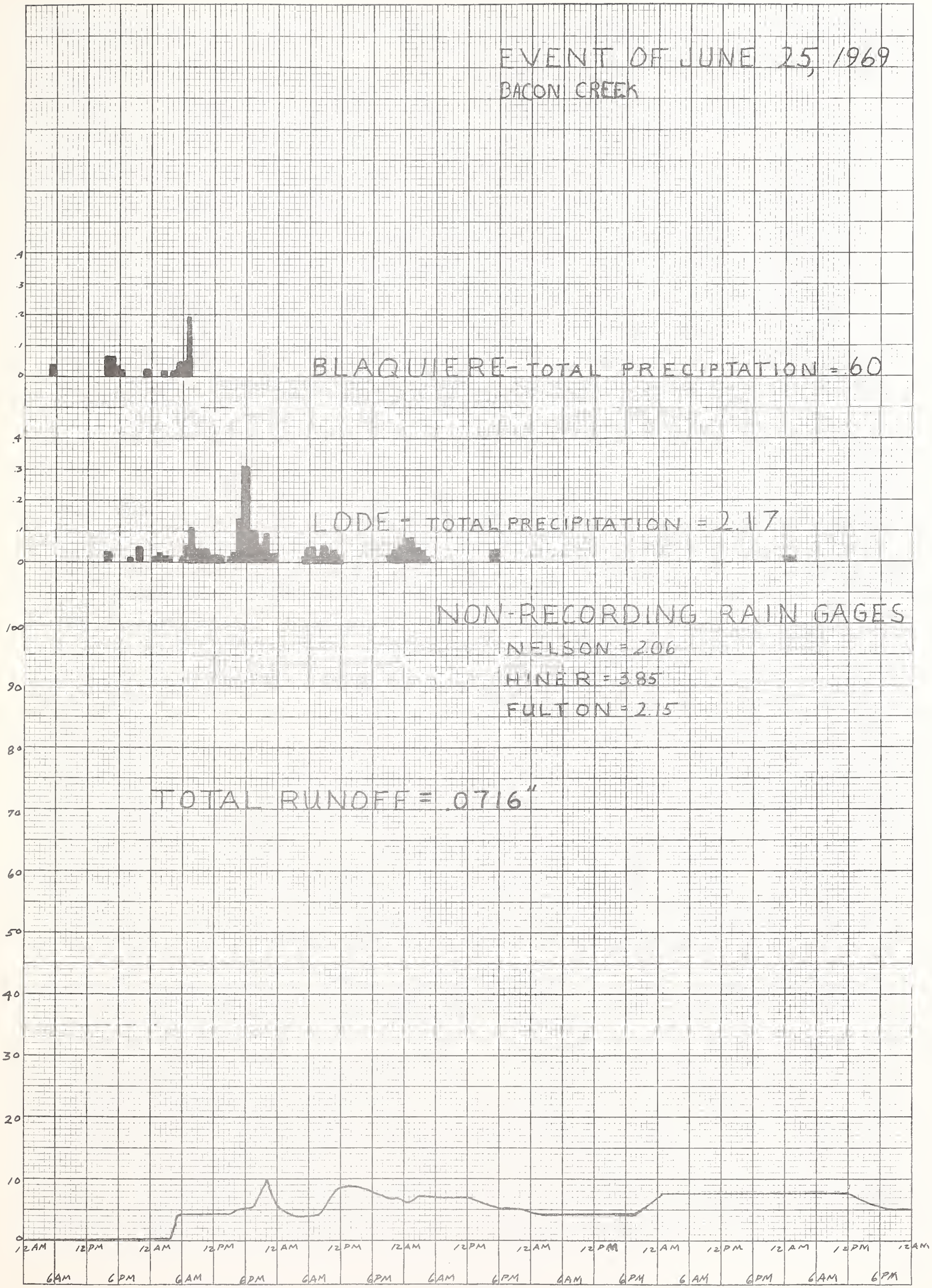

EVENT OF JULY 30, 1965
BACON CREEK
NO RECORD
TOTAL = 0.30
LODE
ROBERTSON
TOTAL = 1.15
NON-RECORDING RAIN GAGES
FULTON 0.27
HINER 1.17
NELSON 0.22
TOTAL RUNOFF = .020 INCHES
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
.5
.4
.3
.2
.1
0
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
7/27
7/28
7/29
7/30
7/31
8/1
8/2
1965


EVENT OF JUNE 13, 1967
BACON CREEK
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
.50" ACC.
MISSING
LODE
TOTAL=1.51"
BLAQUIERE
TOTAL=2.35"
NON-RECORDING RAIN GAGES
FULTON 1.54"
HINER 2.41"
NELSON 1.42"
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF=.0212"
12AM
12PM
6AM
6PM
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
1967

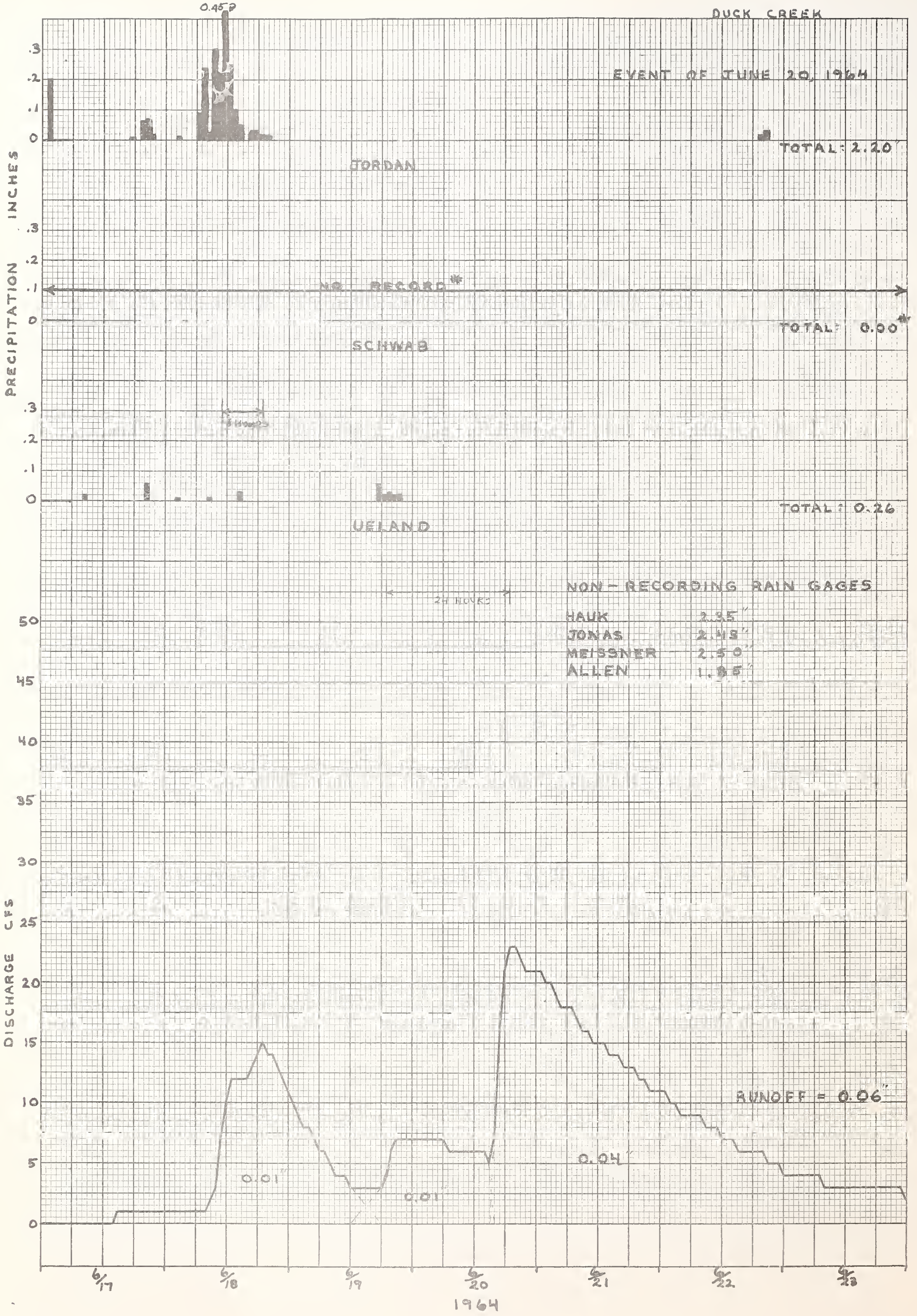

EVENT OF JUNE 8, 1968 BACON CREEK
RAINFALL INCHES
.5
.4
.3
.2
.1
0
LODE
TOTAL = 3.26
.5
.4
.3
.2
.1
0
BLAQUIERE
TOTAL = 2.99
NON-RECORDING GAGES
FULTON 2.68
HINER 3.31
NELSON 2.40
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
6/3
6/4
6/5
6/6
6/7
6/8
6/9

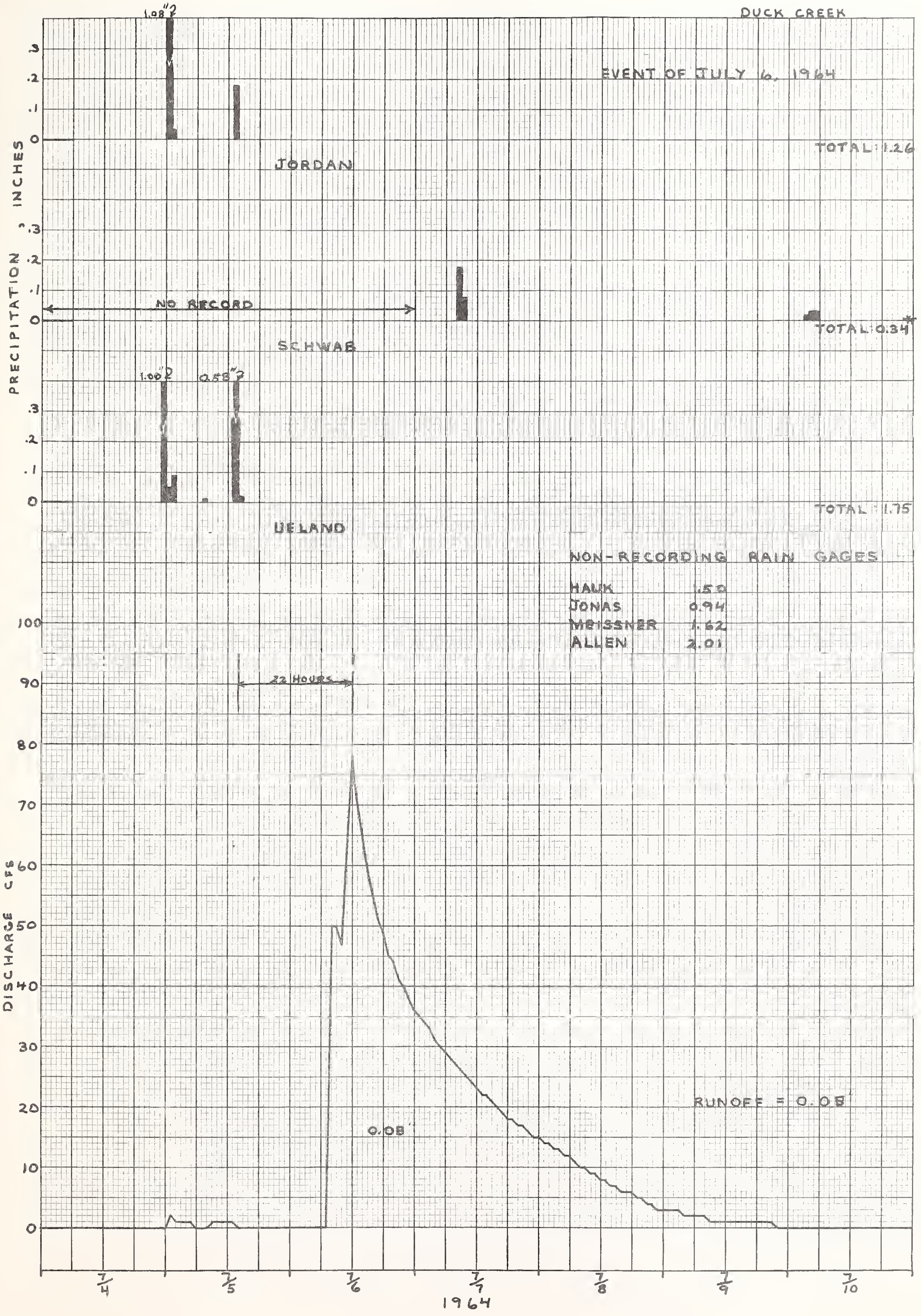

BACON CREEK
3/15 - 3/21 1969
EVENT OF 3/18
RAINFALL NONRECORDING GAGE
.01 HINER
TOTAL Runoff = .310 inches
100
90
80
70
60
50
40
30
20
10
0
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
3/15
3/16
3/17
3/18
3/19
3/20
3/21
1969

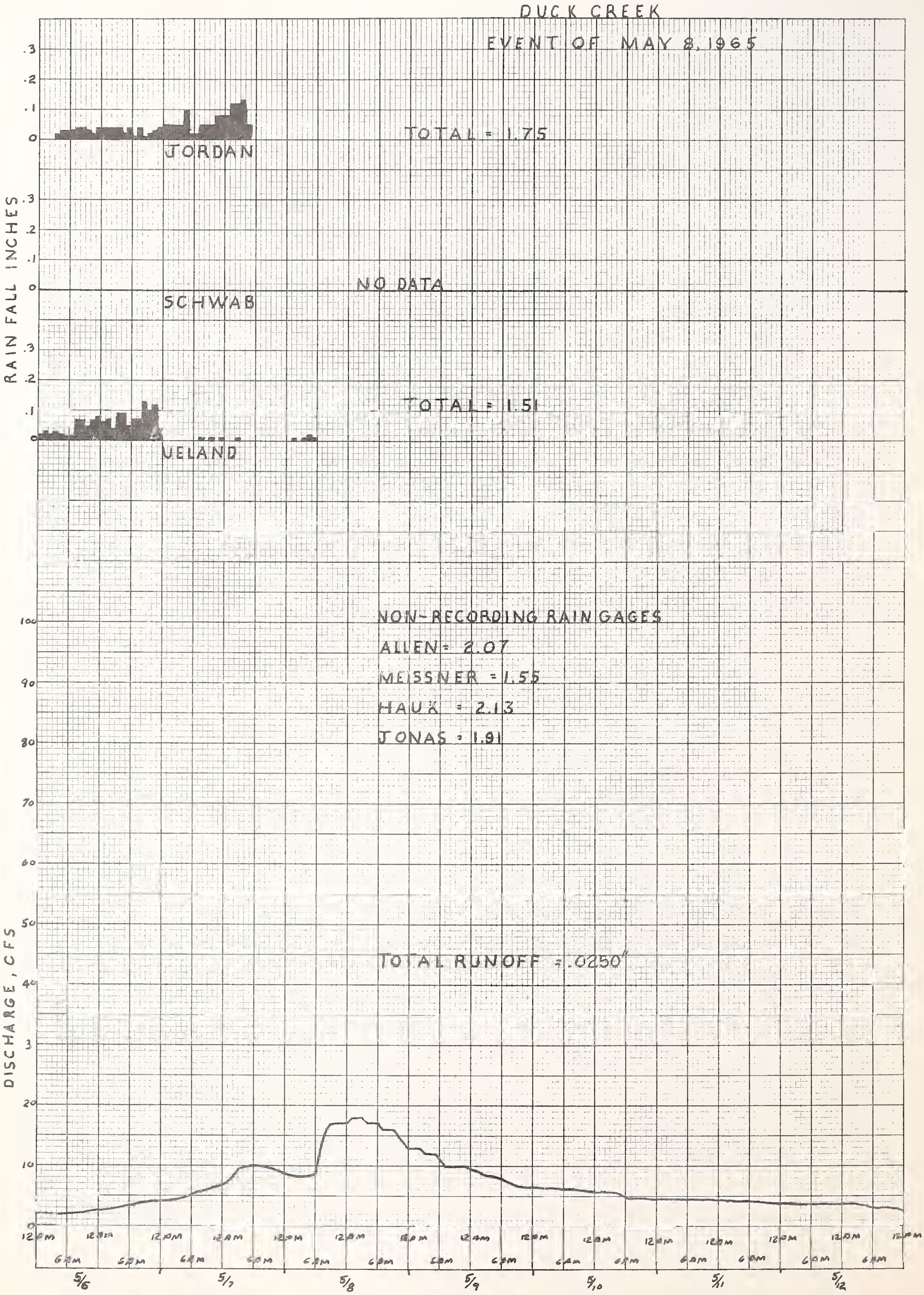

BACON CREEK
3/24-3/30 1969
EVENT OF 3/27
FULTON .01-NON-RECORDING
BLAQUIERE .02
.2
.1
0
100
90
80
70
60
50
40
30
20
10
0
total Runoff = .040 inches
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
3/24
3/25
3/26
3/27
3/28
3/29
3/30
1969

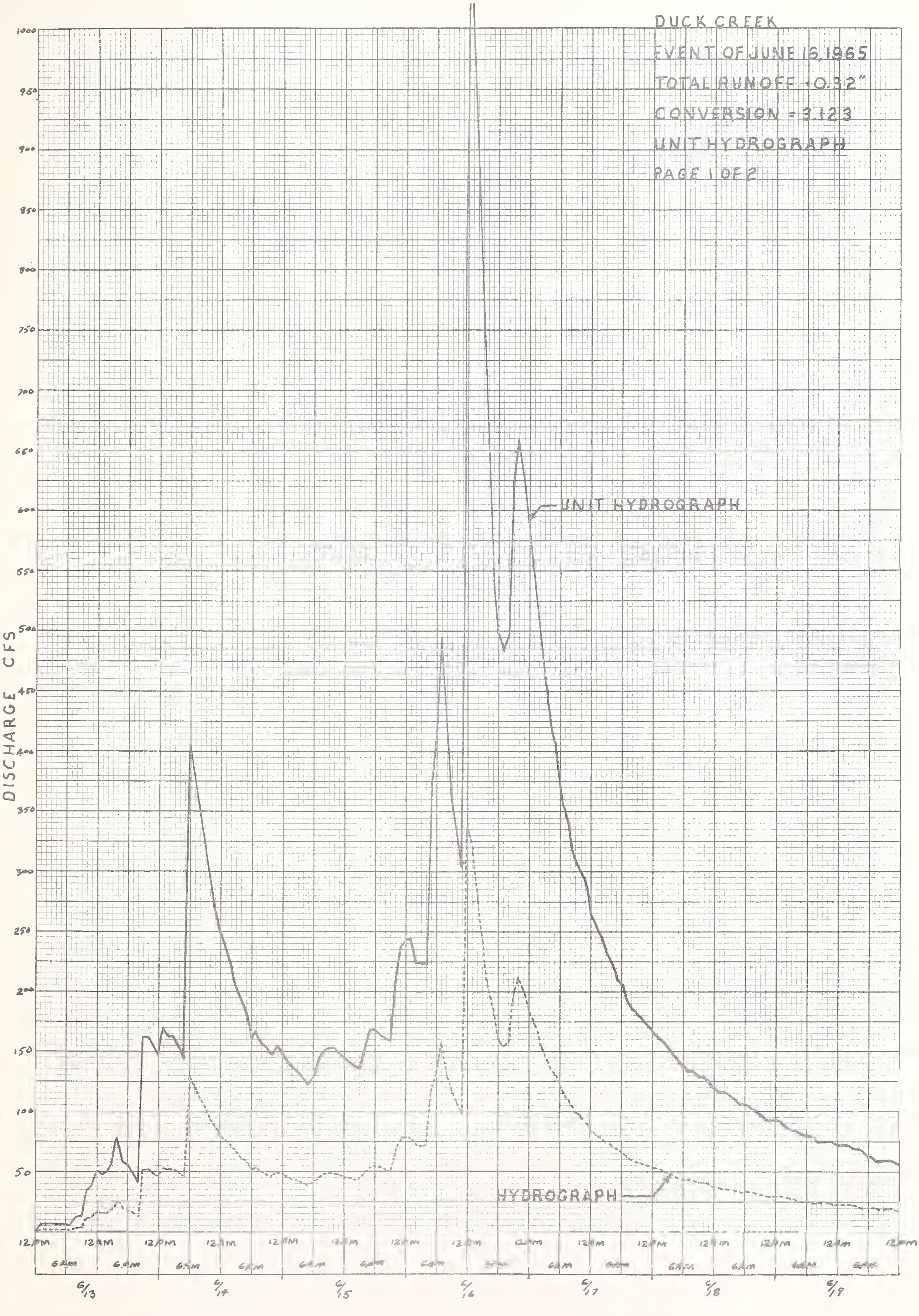

EVENT OF JUNE 25, 1969
BACON CREEK
.4
.3
.2
.1
0
BLAQUIERE - TOTAL PRECIPITATION = .60
.4
.3
.2
.1
0
LODE - TOTAL PRECIPITATION = 2.17
NON-RECORDING RAIN GAGES
NELSON = 2.06
HINER = 3.85
FULTON = 2.15
TOTAL RUNOFF = .0716"
100
90
80
70
60
50
40
30
20
10
0
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6/24
6/25
6/26
6/27
6/28
6/29
6/30

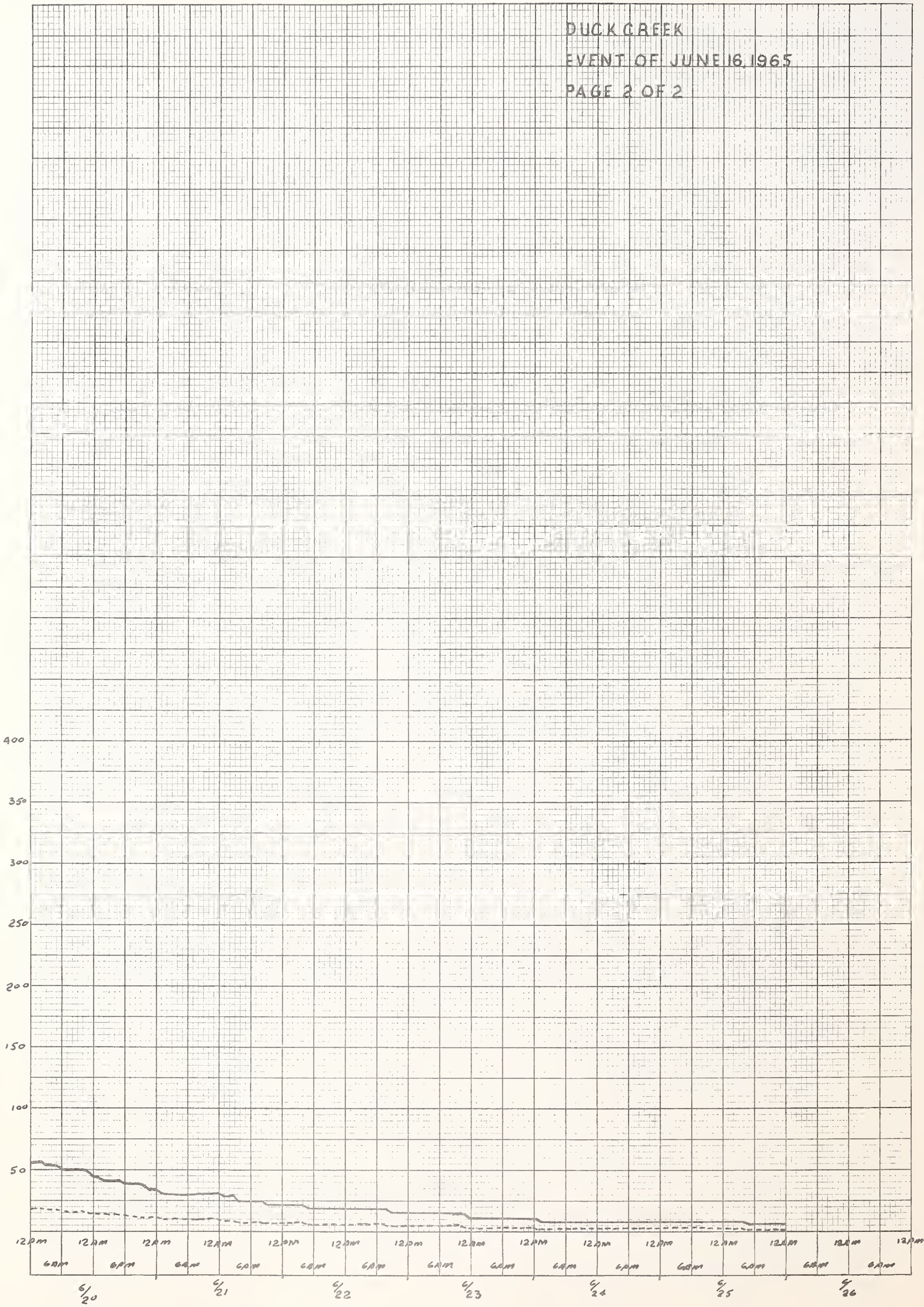
1969

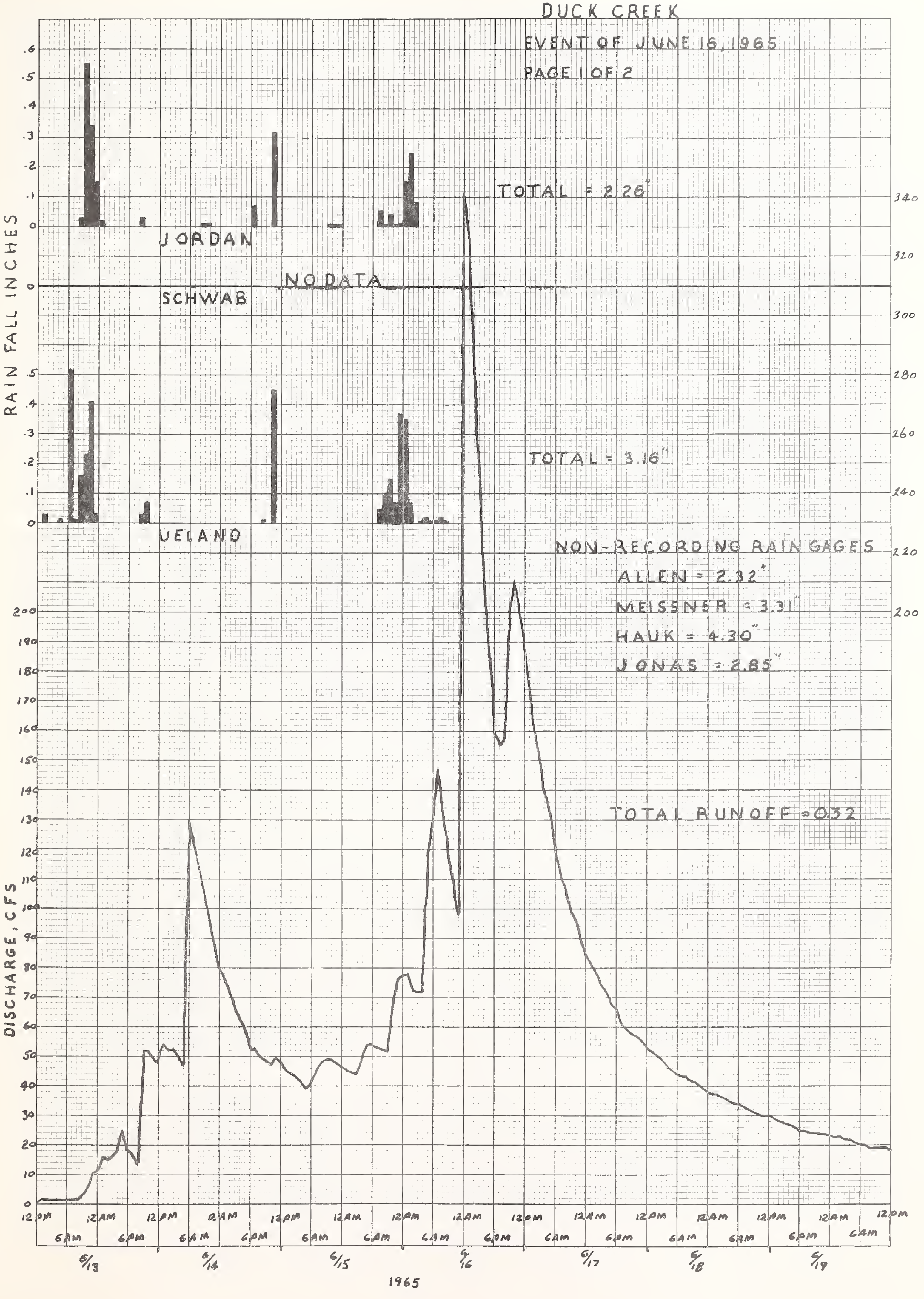

DUCK CREEK
EVENT OF JUNE 20, 1964
0.45?
.3
.2
.1
0
TOTAL: 2.20"
JORDAN
PRECIPITATION INCHES
.3
.2
.1
0
NO RECORD*
TOTAL: 0.00*
SCHWAB
.3
.2
.1
0
3 Hours
TOTAL: 0.26
UELAND
24 HOURS
NON-RECORDING RAIN GAGES
HAUK 2.35"
JONAS 2.43"
MEISSNER 2.50"
ALLEN 1.85"
50
45
40
35
30
25
20
15
10
5
0
DISCHARGE CFS
RUNOFF = 0.06"
0.01"
0.01
0.04"
6/17
6/18
6/19
6/20
6/21
6/22
6/23
1964

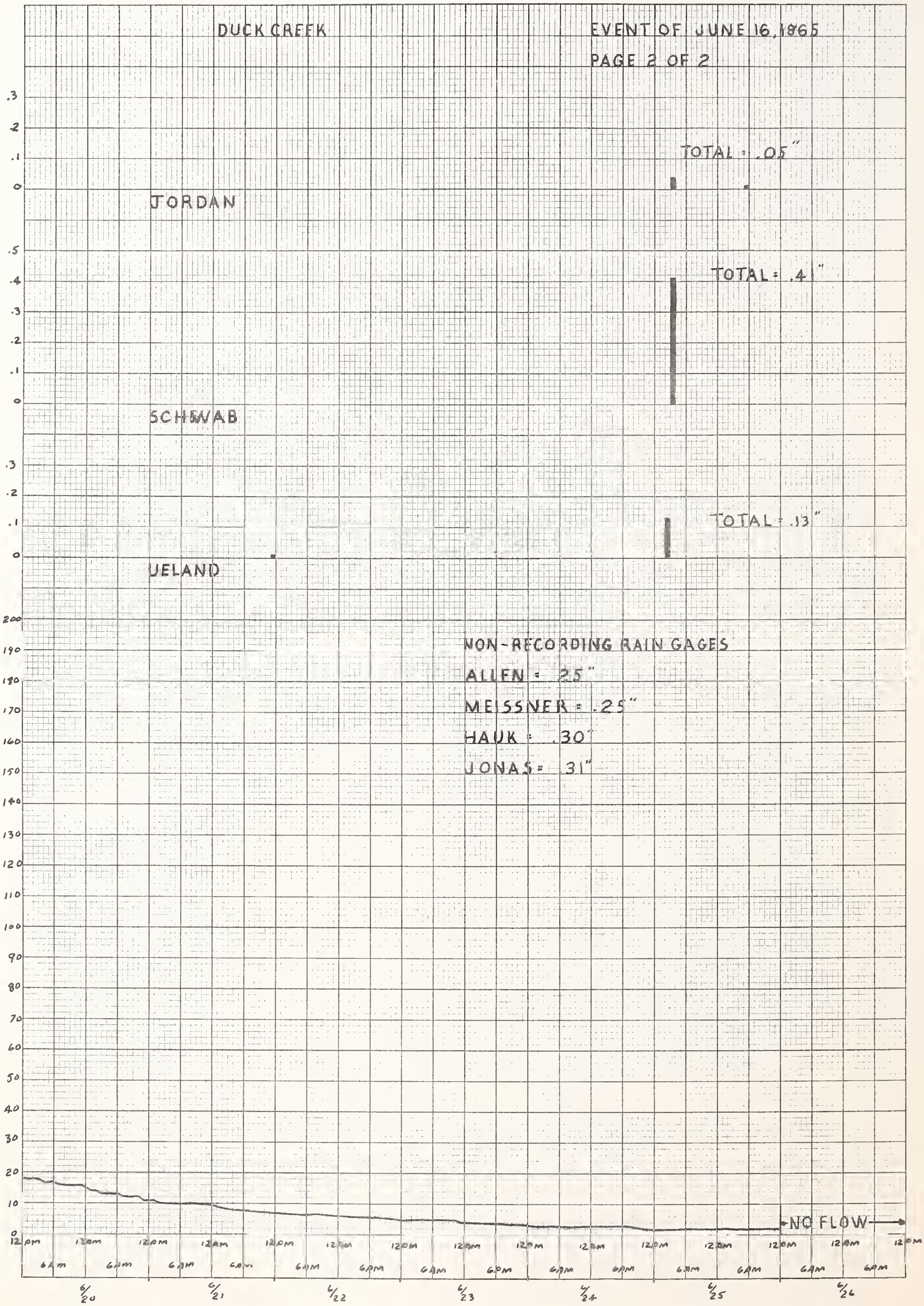

DUCK CREEK
EVENT OF JULY 6, 1964
PRECIPITATION, INCHES
1.08"?
.3
.2
.1
0
TOTAL: 1.26
JORDAN
.3
.2
.1
0
NO RECORD
TOTAL: 0.34*
SCHWAB
1.00"?
0.58"?
.3
.2
.1
0
TOTAL: 1.75
UELAND
NON-RECORDING RAIN GAGES
HAUK 1.50
JONAS 0.94
MEISSNER 1.62
ALLEN 2.01
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
22 HOURS
RUNOFF = 0.08"
0.08"
7/4
7/5
7/6
7/7
7/8
7/9
7/10
1964


DUCK CREEK
EVENT OF MAY 8, 1965
RAIN FALL INCHES
.3
.2
.1
0
TOTAL = 1.75
JORDAN
NO DATA
SCHWAB
TOTAL = 1.51
UELAND
NON-RECORDING RAIN GAGES
ALLEN = 2.07
MEISSNER = 1.55
HAUX = 2.13
JONAS = 1.91
TOTAL RUNOFF = .0250"
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
12 PM
12 AM
6 AM
6 PM
5/6
5/7
5/8
5/9
5/10
5/11
5/12


DUCK CREEK
EVENT OF JUNE 16, 1965
TOTAL RUNOFF = 0.32"
CONVERSION = 3.123
UNIT HYDROGRAPH
PAGE 1 OF 2
UNIT HYDROGRAPH
HYDROGRAPH
DISCHARGE CFS
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6/13
6/14
6/15
6/16
6/17
6/18
6/19


DUCK CREEK
EVENT OF JUNE 16, 1965
PAGE 2 OF 2


DUCK CREEK
EVENT OF JUNE 16, 1965
PAGE 1 OF 2
RAIN FALL INCHES
.6
.5
.4
.3
.2
.1
0
JORDAN
TOTAL = 2.26"
0
SCHWAB
NO DATA
.5
.4
.3
.2
.1
0
UELAND
TOTAL = 3.16"
NON-RECORDING RAIN GAGES
ALLEN = 2.32"
MEISSNER = 3.31"
HAUK = 4.30"
JONAS = 2.85"
TOTAL RUNOFF = 0.32
DISCHARGE, CFS
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
340
320
300
280
260
240
220
200
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 AM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6/13
6/14
6/15
6/16
6/17
6/18
6/19
1965



DUCK CREEK

EVENT OF JUNE 16, 1965

PAGE 2 OF 2

NON-RECORDING RAIN GAGES

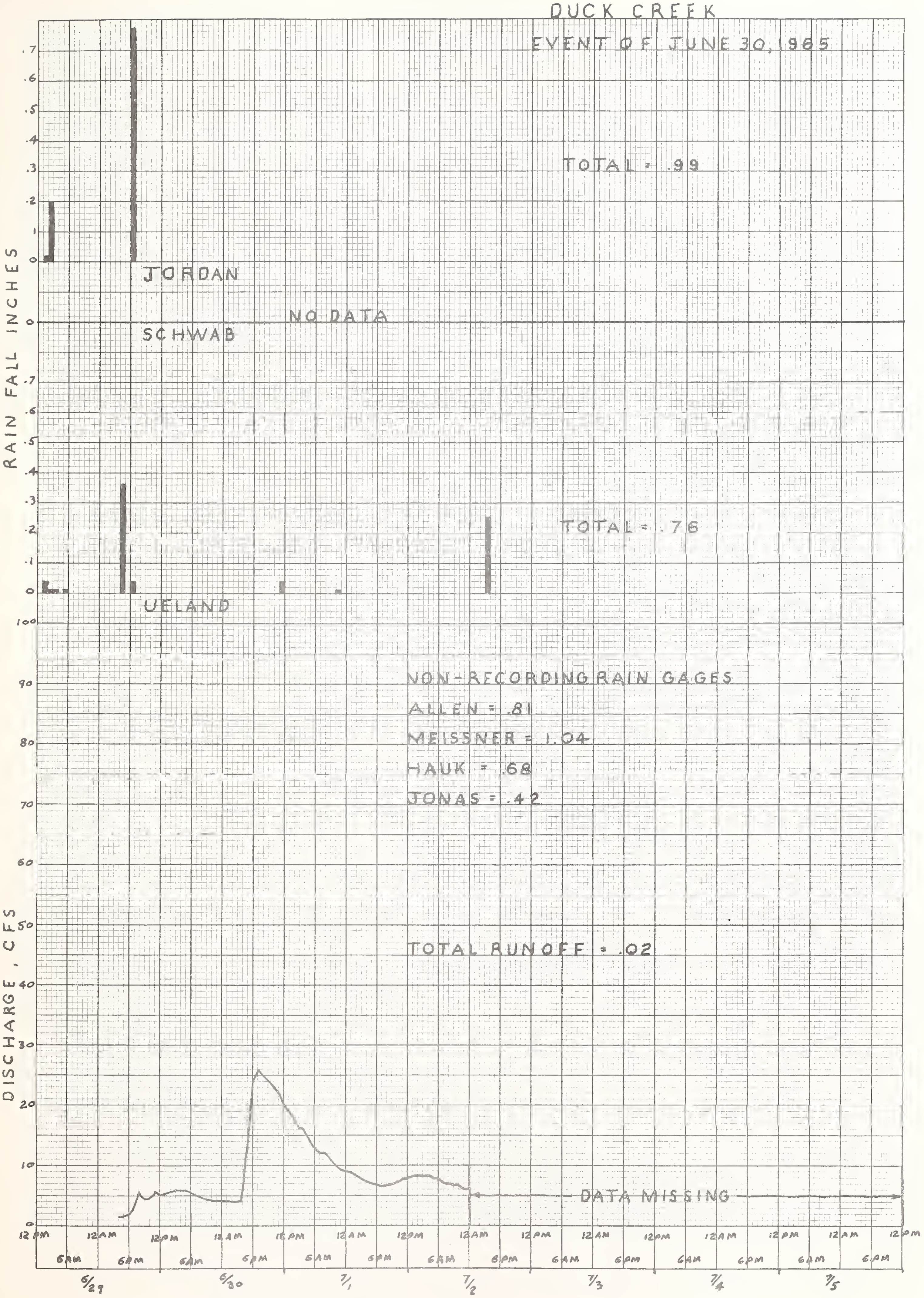
ALLEN = .25"

MEISSNER = .25"

HAUK = .30"

JONAS = .31"

DUCK CREEK
EVENT OF JUNE 30, 1965



NON-RECORDING RAIN GAGES

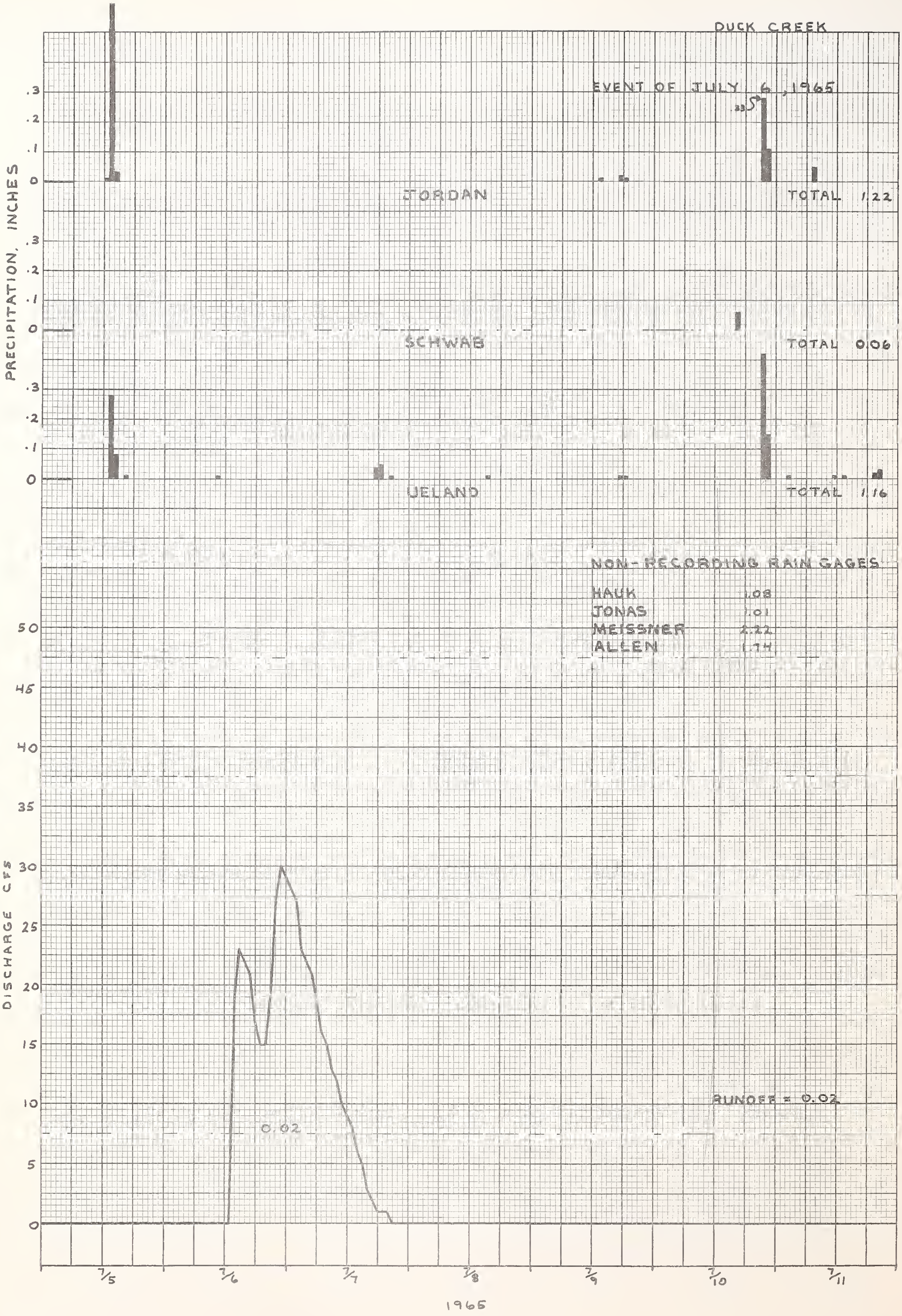
ALLEN = .81

MEISSNER = 1.04

HAUK = .68

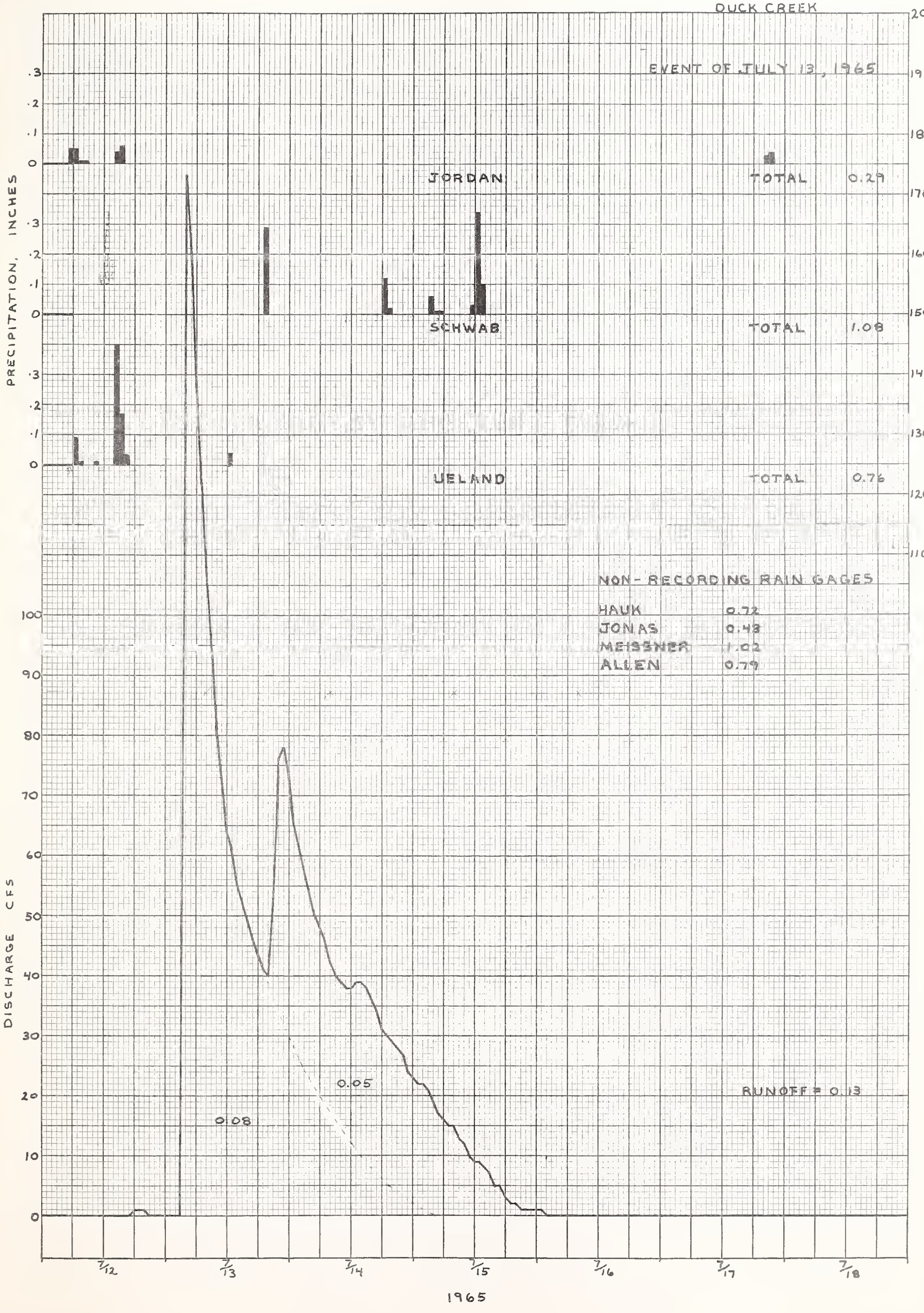
JONAS = .42

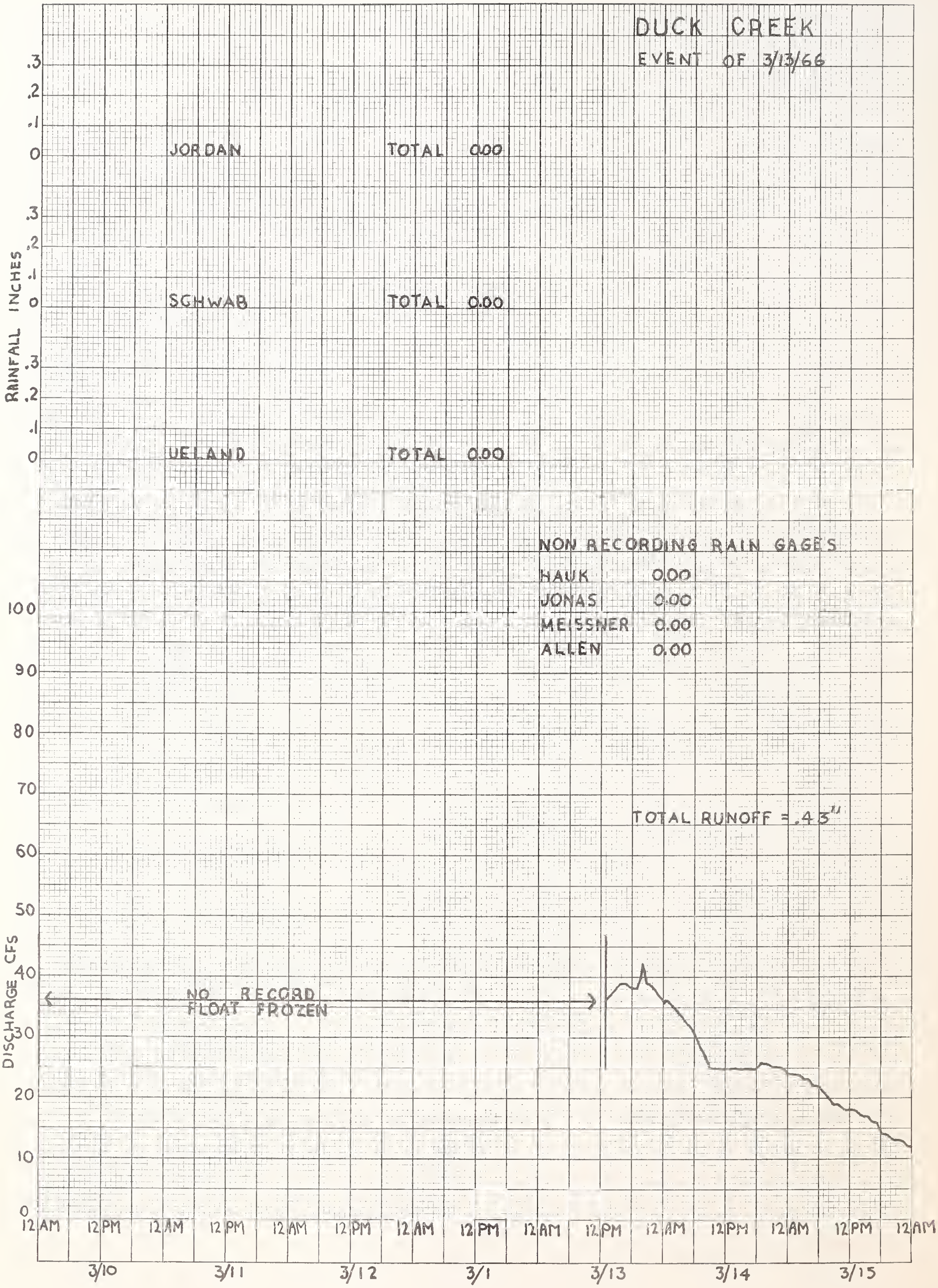
TOTAL RUNOFF = .02

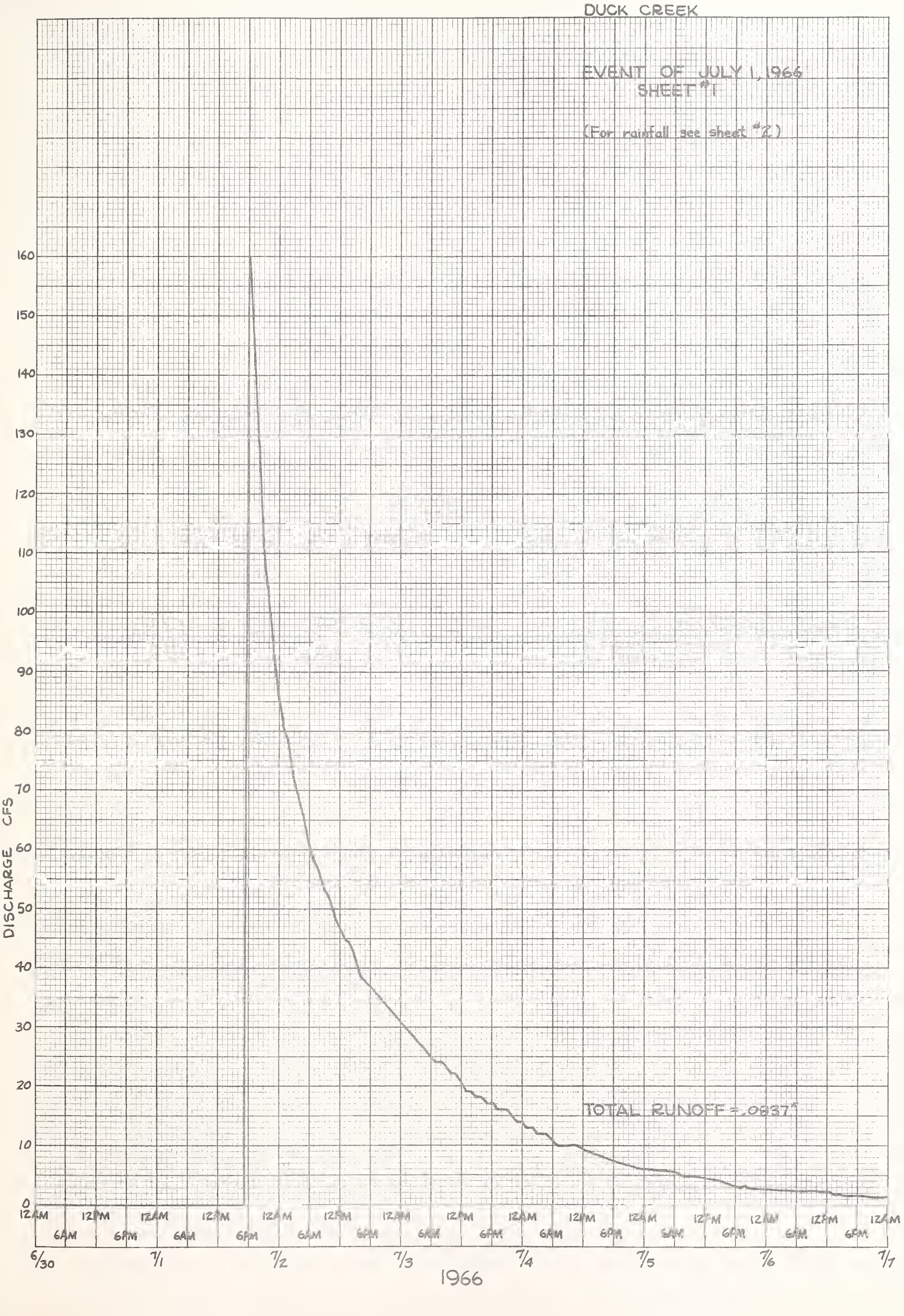


NON-RECORDING RAIN GAGES

HAUK	1.08
JONAS	1.01
MEISSNER	2.22
ALLEN	1.14


DUCK CREEK
EVENT OF JULY 13, 1965
PRECIPITATION, INCHES
.3
.2
.1
0
JORDAN
TOTAL 0.29
SCHWAB
TOTAL 1.08
UELAND
TOTAL 0.76
NON-RECORDING RAIN GAGES
HAUK 0.72
JONAS 0.48
MEISSNER 1.02
ALLEN 0.79
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
0.08
0.05
RUNOFF = 0.13
200
190
180
170
160
150
140
130
120
110
7/12
7/13
7/14
7/15
7/16
7/17
7/18
1965


DUCK CREEK
EVENT OF 3/13/66
RAINFALL INCHES
.3
.2
.1
0
JORDAN
TOTAL 0.00
SCHWAB
TOTAL 0.00
UELAND
TOTAL 0.00
NON RECORDING RAIN GAGES
HAUK 0.00
JONAS 0.00
MEISSNER 0.00
ALLEN 0.00
TOTAL RUNOFF = .43"
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
NO RECORD
FLOAT FROZEN
12 AM
12 PM
3/10
3/11
3/12
3/1
3/13
3/14
3/15



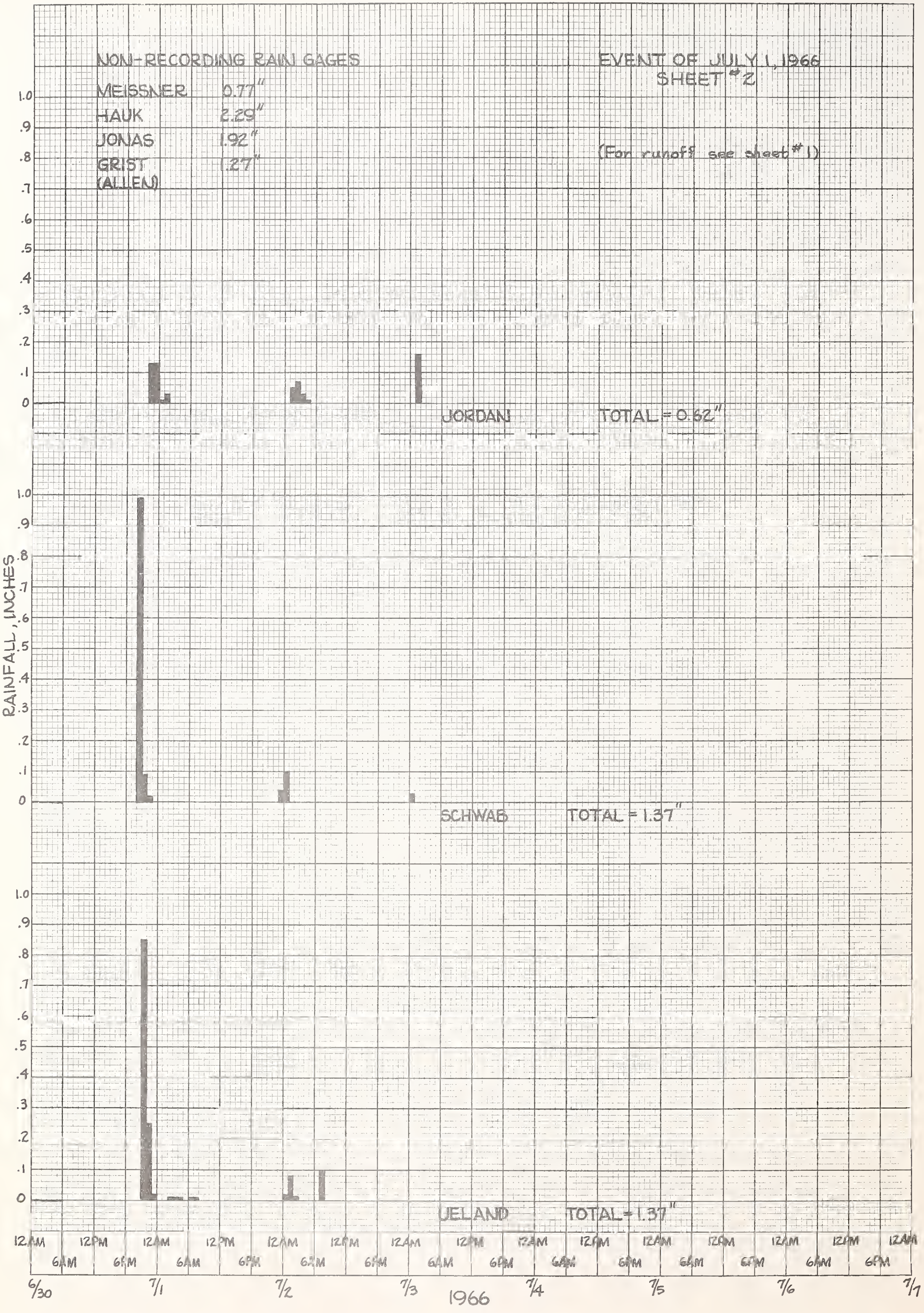
DUCK CREEK

EVENT OF JULY 1, 1966
SHEET #1

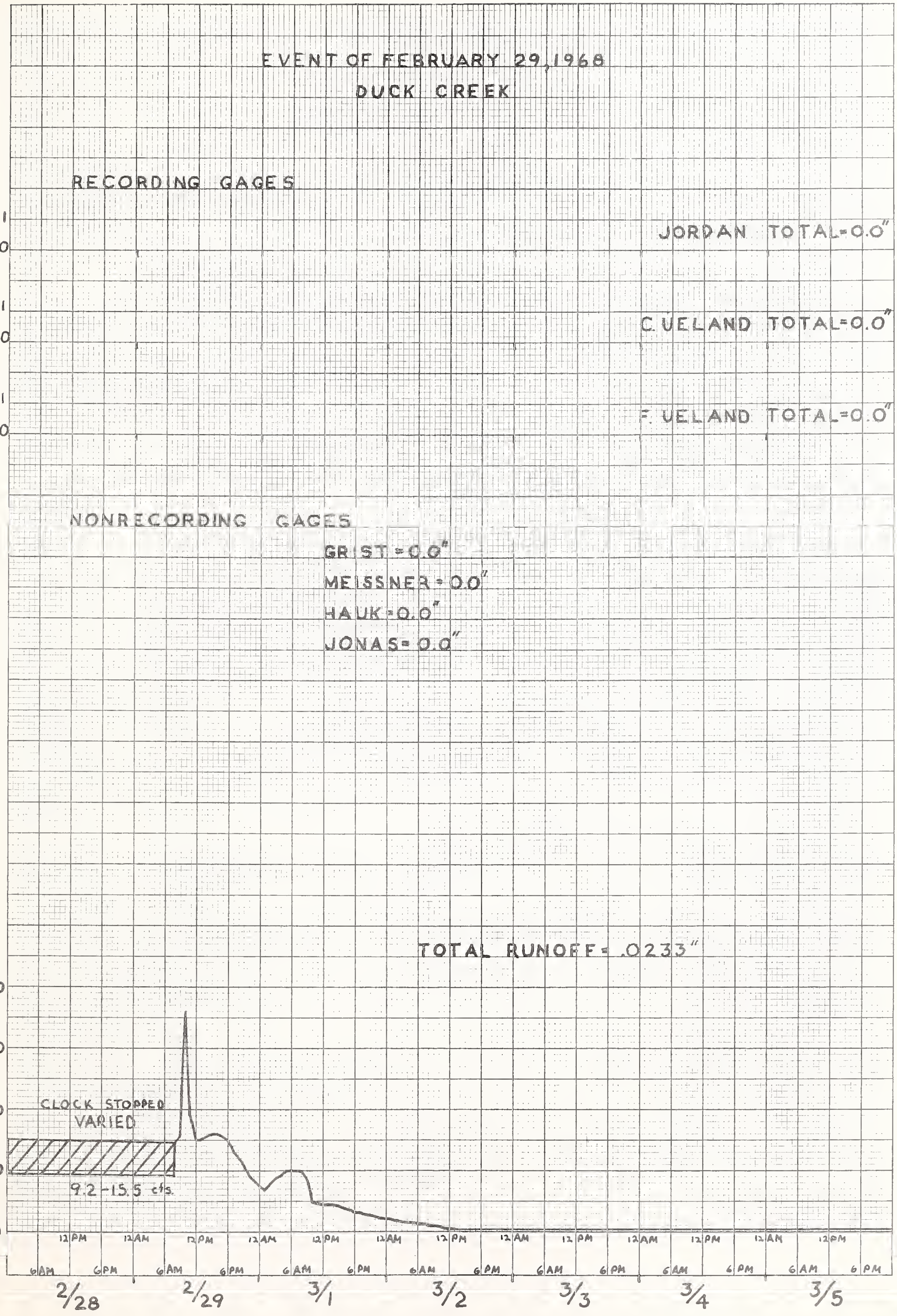
(For rainfall see sheet #2)

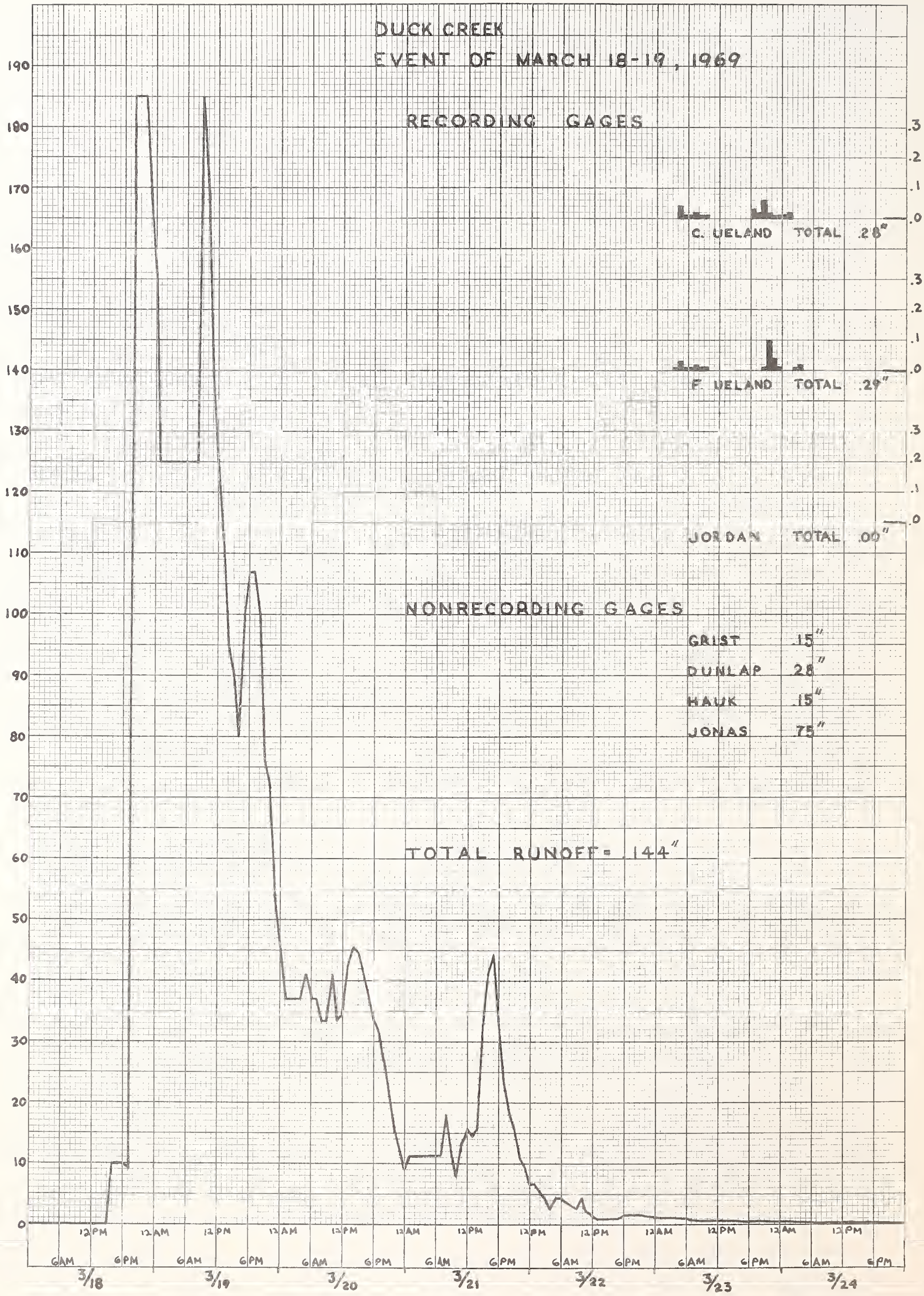
TOTAL RUNOFF = .0837"

DUCK CREEK

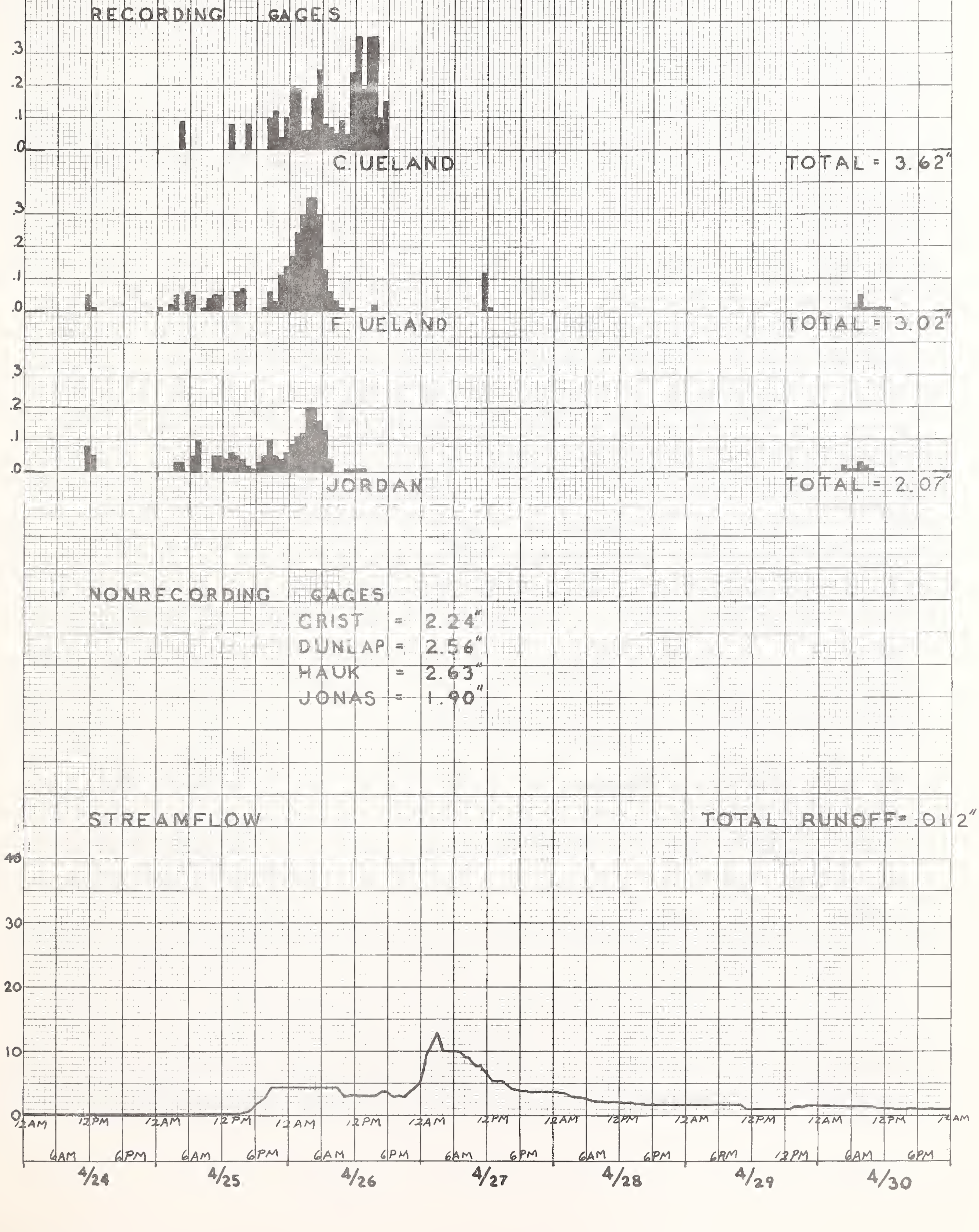

NON-RECORDING RAIN GAGES
MEISSNER 0.77"
HAUK 2.29"
JONAS 1.92"
GRIST (ALLEN) 1.27"
EVENT OF JULY 1, 1966
SHEET #2
(For runoff see sheet #1)
JORDAN TOTAL = 0.62"
SCHWAB TOTAL = 1.37"
UELAND TOTAL = 1.37"
RAINFALL, INCHES
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
12AM
6AM
12PM
6PM
6/30
7/1
7/2
7/3
7/4
7/5
7/6
7/7
1966

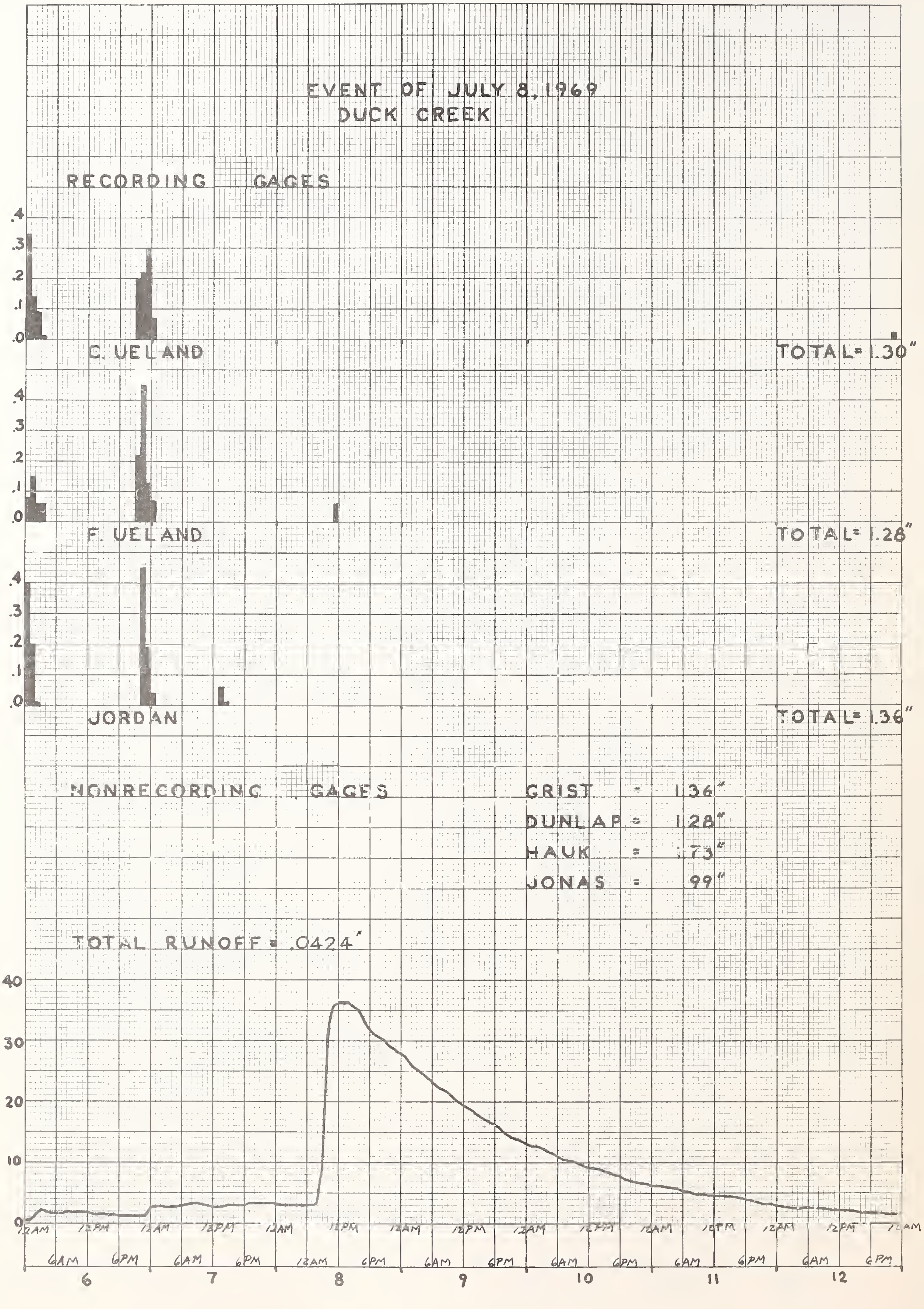
EVENT OF FEBRUARY 29, 1968
DUCK CREEK

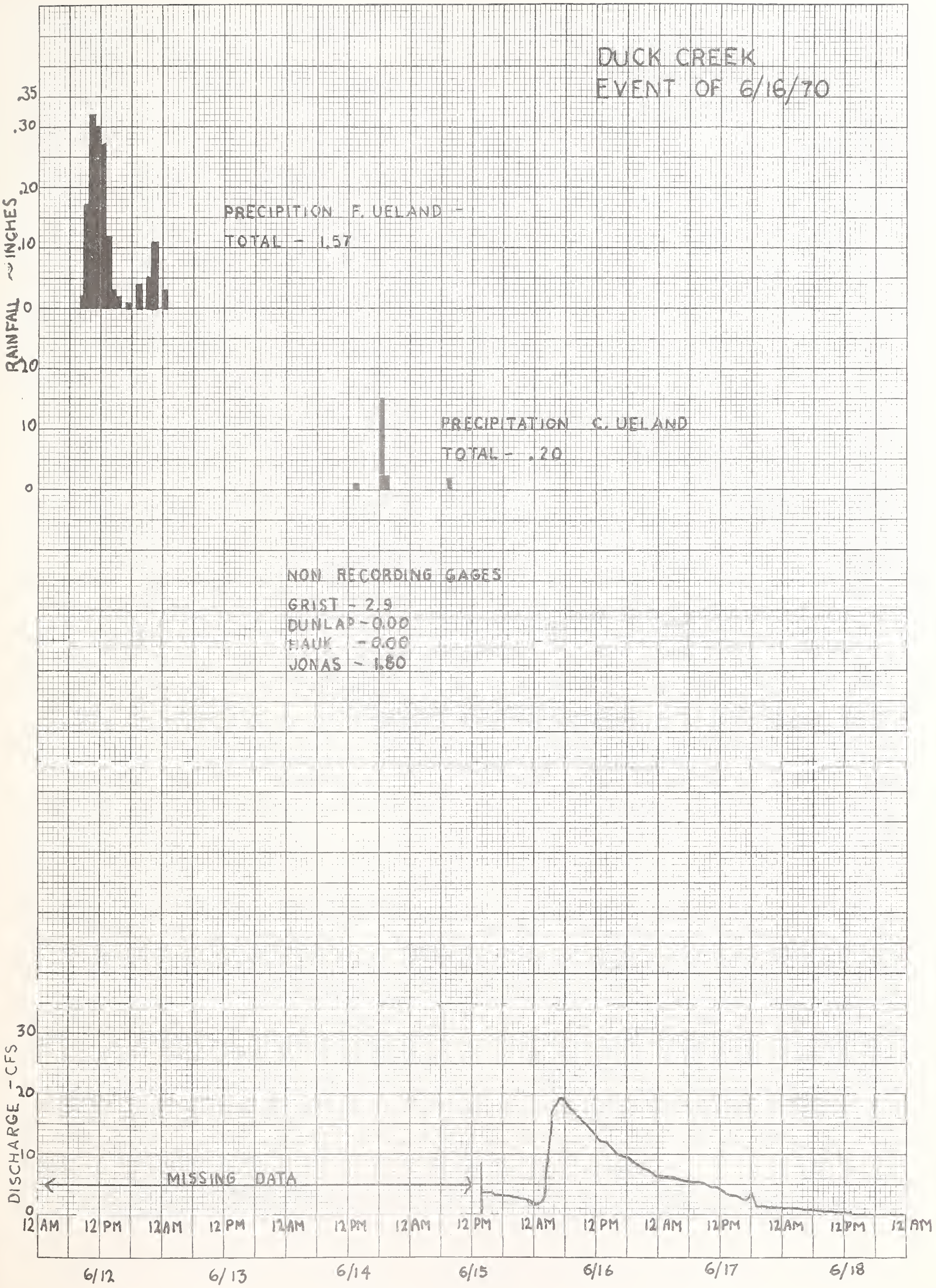



DUCK CREEK
EVENT OF MARCH 18-19, 1969
RECORDING GAGES
C. UELAND TOTAL .28"
F. UELAND TOTAL .29"
JORDAN TOTAL .00"
.3
.2
.1
.0
NONRECORDING GAGES
GRIST .15"
DUNLAP .28"
HAUK .15"
JONAS .75"
TOTAL RUNOFF = .144"
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
12 PM
12 AM
6 AM
6 PM
3/18
3/19
3/20
3/21
3/22
3/23
3/24

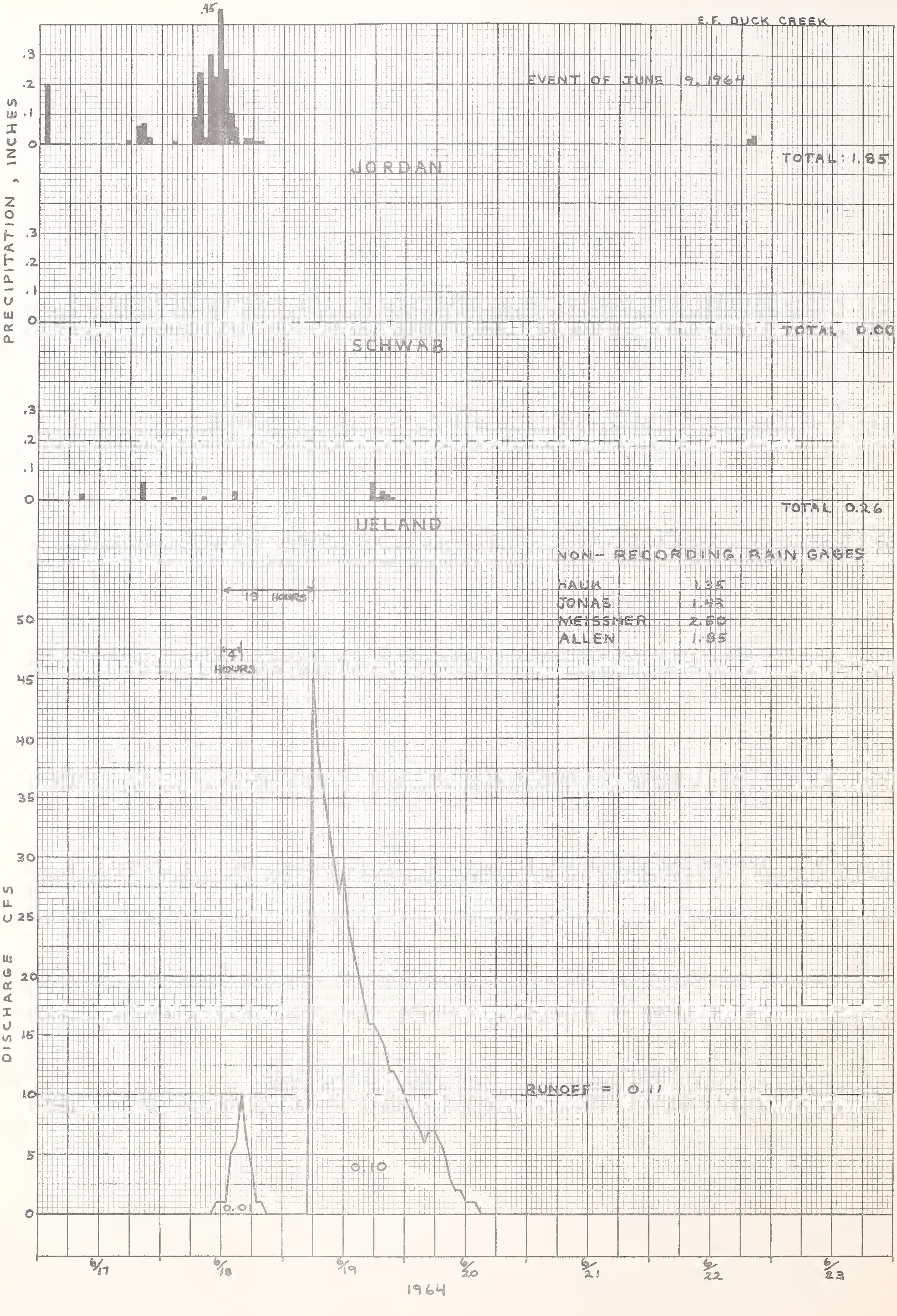
EVENT OF APRIL 27, 1969
DUCK CREEK

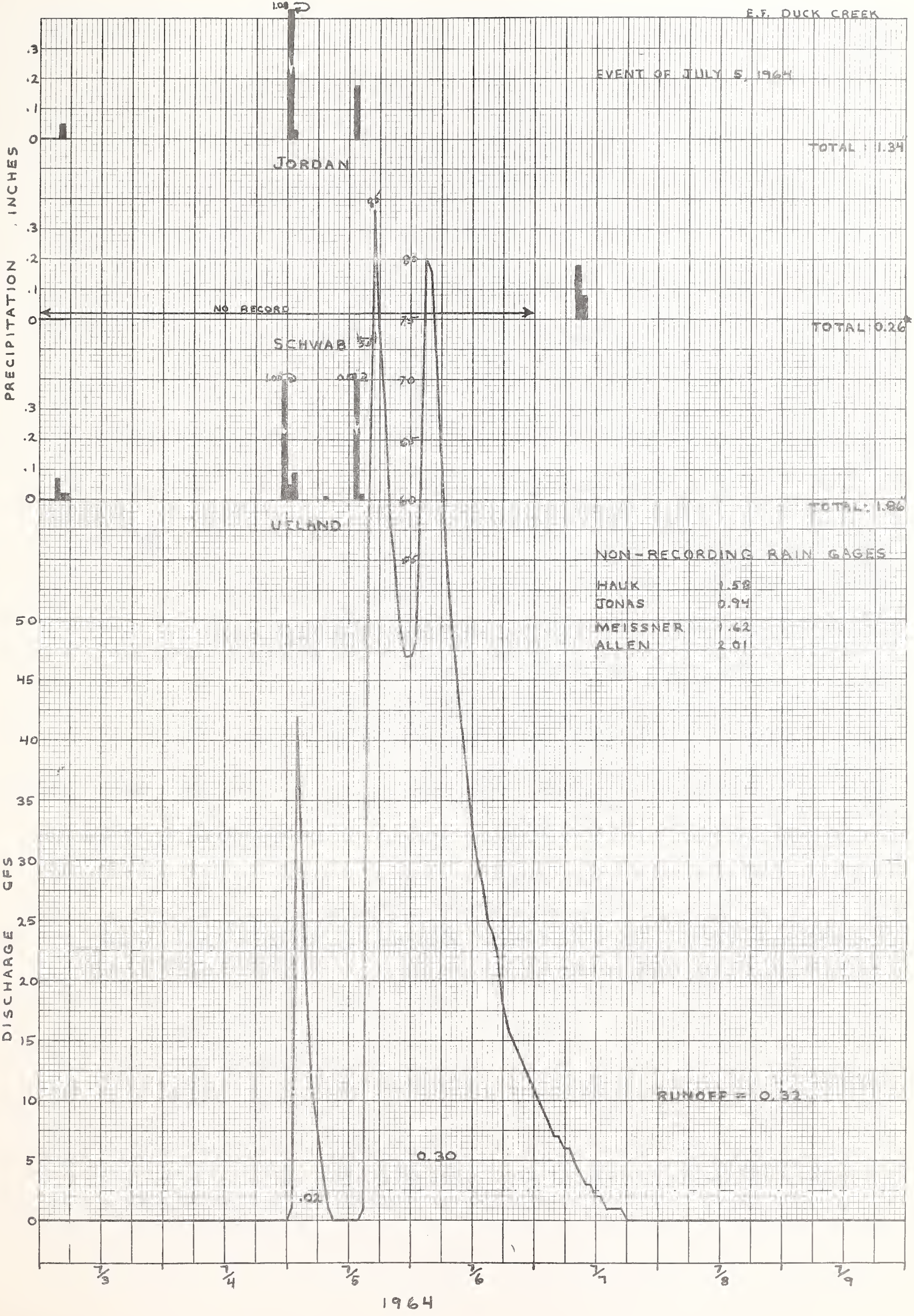


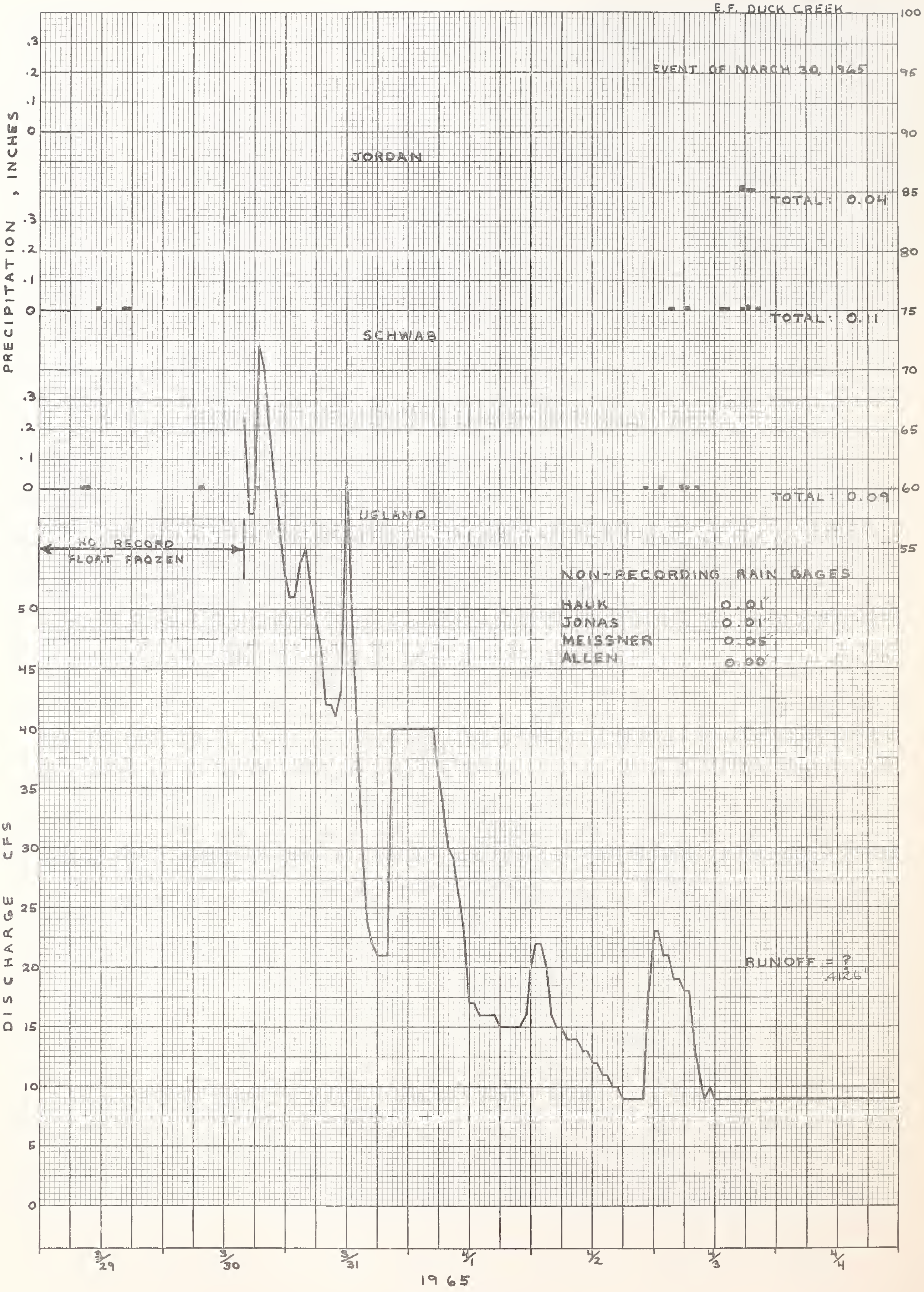

EVENT OF JULY 8, 1969
DUCK CREEK
RECORDING GAGES
.4
.3
.2
.1
.0
C. UELAND
TOTAL= 1.30"
.4
.3
.2
.1
.0
F. UELAND
TOTAL= 1.28"
.4
.3
.2
.1
.0
JORDAN
TOTAL= 1.36"
NONRECORDING GAGES
GRIST = 1.36"
DUNLAP = 1.28"
HAUK = .73"
JONAS = .99"
TOTAL RUNOFF = .0424"
40
30
20
10
0
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
6AM
6PM
6AM
6PM
12AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6
7
8
9
10
11
12

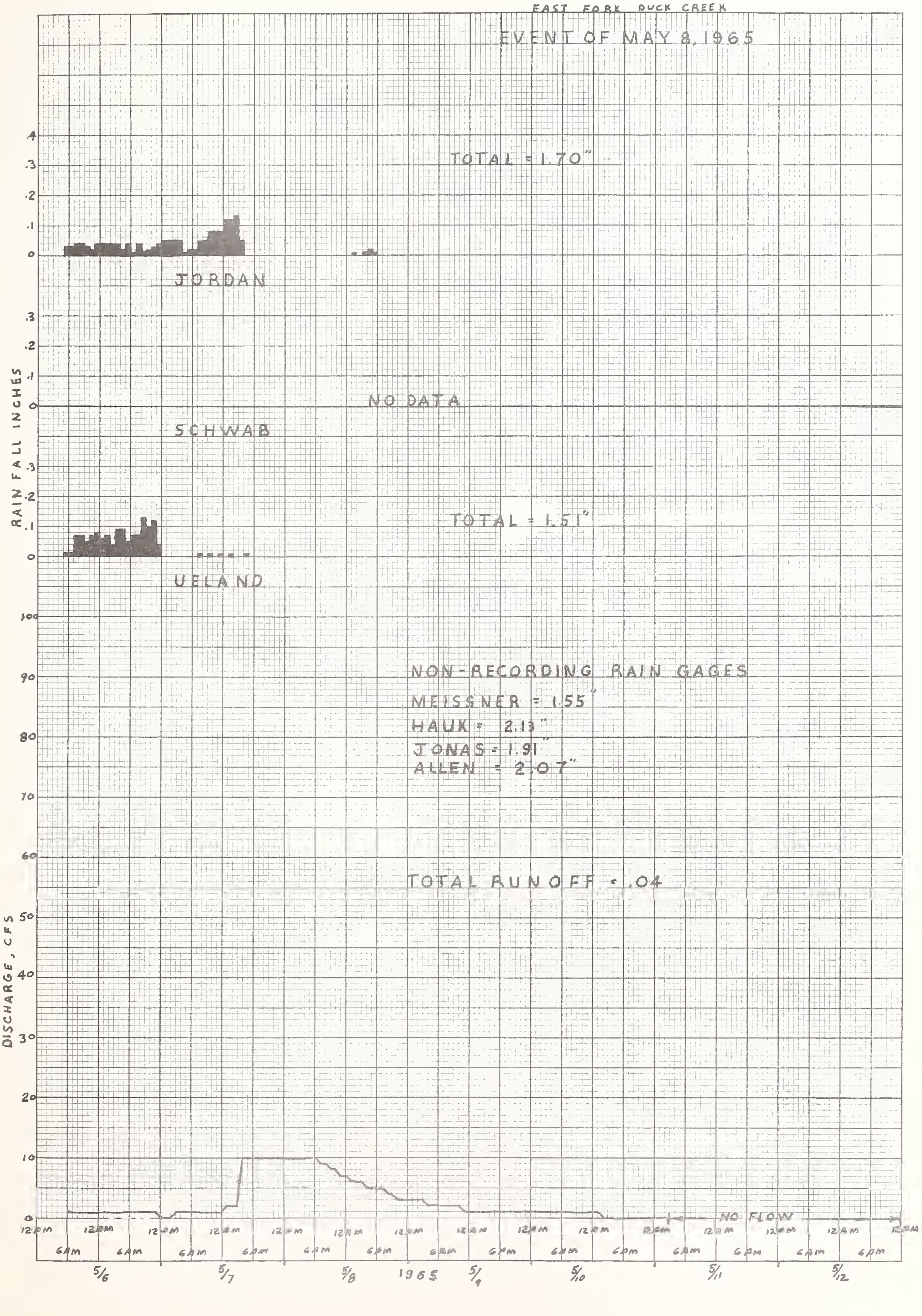

DUCK CREEK
EVENT OF 6/16/70
RAINFALL ~ INCHES
.35
.30
.20
.10
0
.20
.10
0
PRECIPITION F. UELAND -
TOTAL - 1.57
PRECIPITATION C. UELAND
TOTAL - .20
NON RECORDING GAGES
GRIST - 2.9
DUNLAP - 0.00
HAUK - 0.00
JONAS - 1.80
DISCHARGE - CFS
30
20
10
0
MISSING DATA
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
6/12
6/13
6/14
6/15
6/16
6/17
6/18

1970


E.F. DUCK CREEK
EVENT OF JUNE 19, 1964
.45
.3
.2
.1
0
PRECIPITATION , INCHES
JORDAN
TOTAL: 1.85
SCHWAB
TOTAL 0.00
UELAND
TOTAL 0.26
NON- RECORDING RAIN GAGES
HAUK 1.35
JONAS 1.43
MEISSNER 2.60
ALLEN 1.85
19 HOURS
4 HOURS
50
45
40
35
30
25
20
15
10
5
0
DISCHARGE CFS
RUNOFF = 0.11
0.10
0.01
6/17
6/18
6/19
6/20
6/21
6/22
6/23
1964


E.F. DUCK CREEK
EVENT OF JULY 5, 1964
PRECIPITATION, INCHES
.3
.2
.1
0
1.08"
JORDAN
TOTAL: 1.34"
NO RECORD
SCHWAB
TOTAL: 0.26"*
1.00"
0.62"
UELAND
TOTAL: 1.86"
85
80
75
70
65
60
55
NON-RECORDING RAIN GAGES
HAUK 1.58
JONAS 0.94
MEISSNER 1.62
ALLEN 2.01
DISCHARGE CFS
50
45
40
35
30
25
20
15
10
5
0
RUNOFF = 0.32
0.30
.02
7/3
7/4
7/5
7/6
7/7
7/8
7/9
1964


E.F. DUCK CREEK
EVENT OF MARCH 30, 1965
JORDAN
TOTAL: 0.04"
SCHWAB
TOTAL: 0.11
UELAND
TOTAL: 0.09"
PRECIPITATION, INCHES
.3
.2
.1
0
NO RECORD
FLOAT FROZEN
NON-RECORDING RAIN GAGES
HAUK 0.01"
JONAS 0.01"
MEISSNER 0.05"
ALLEN 0.00"
RUNOFF = ?
.4126"
DISCHARGE CFS
50
45
40
35
30
25
20
15
10
5
0
100
95
90
85
80
75
70
65
60
55
3/29
3/30
3/31
4/1
4/2
4/3
4/4
1965



EAST FORK DUCK CREEK

EVENT OF MAY 8, 1965

TOTAL = 1.70"

NO DATA

TOTAL = 1.51"

NON-RECORDING RAIN GAGES

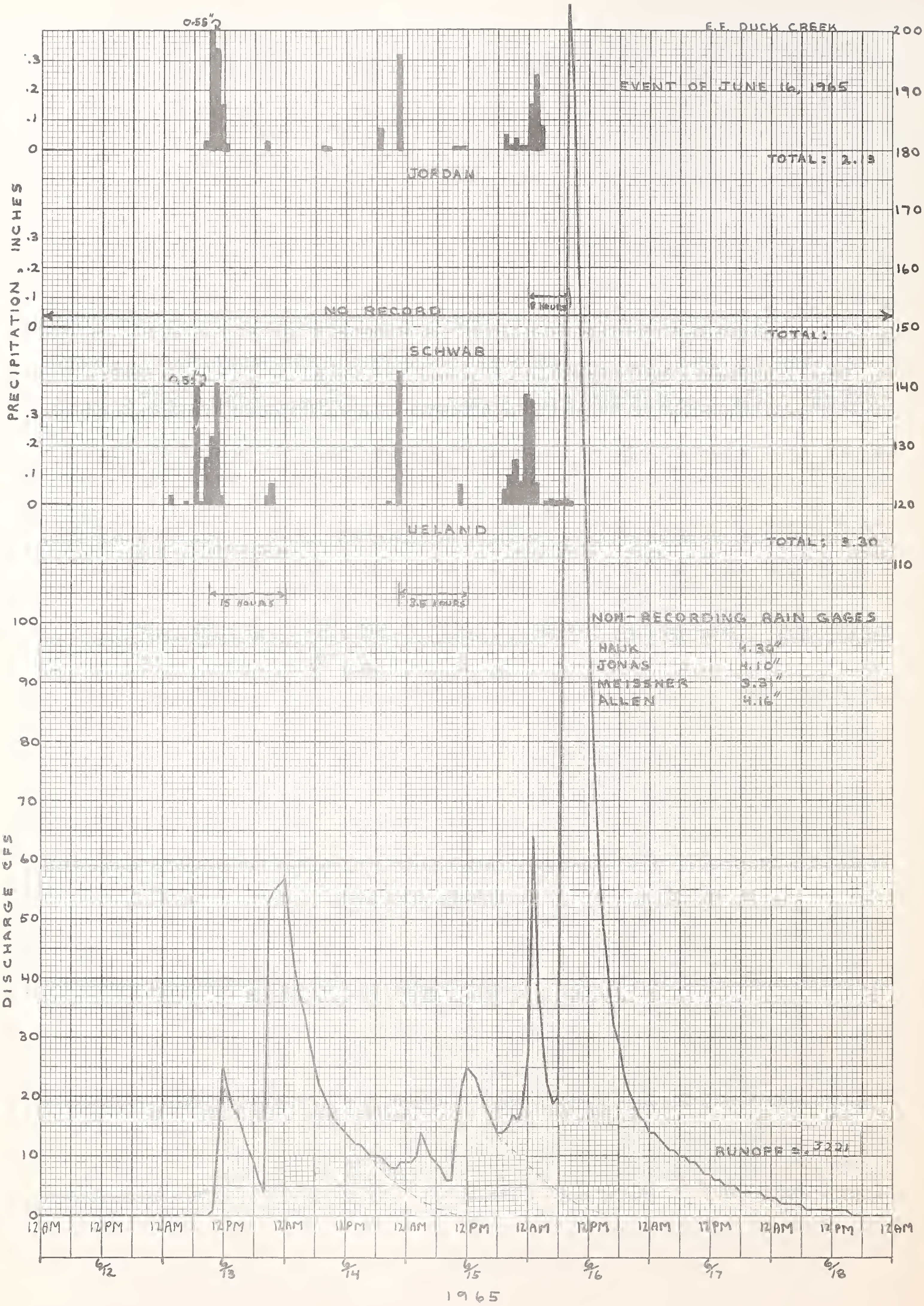
MEISSNER = 1.55"

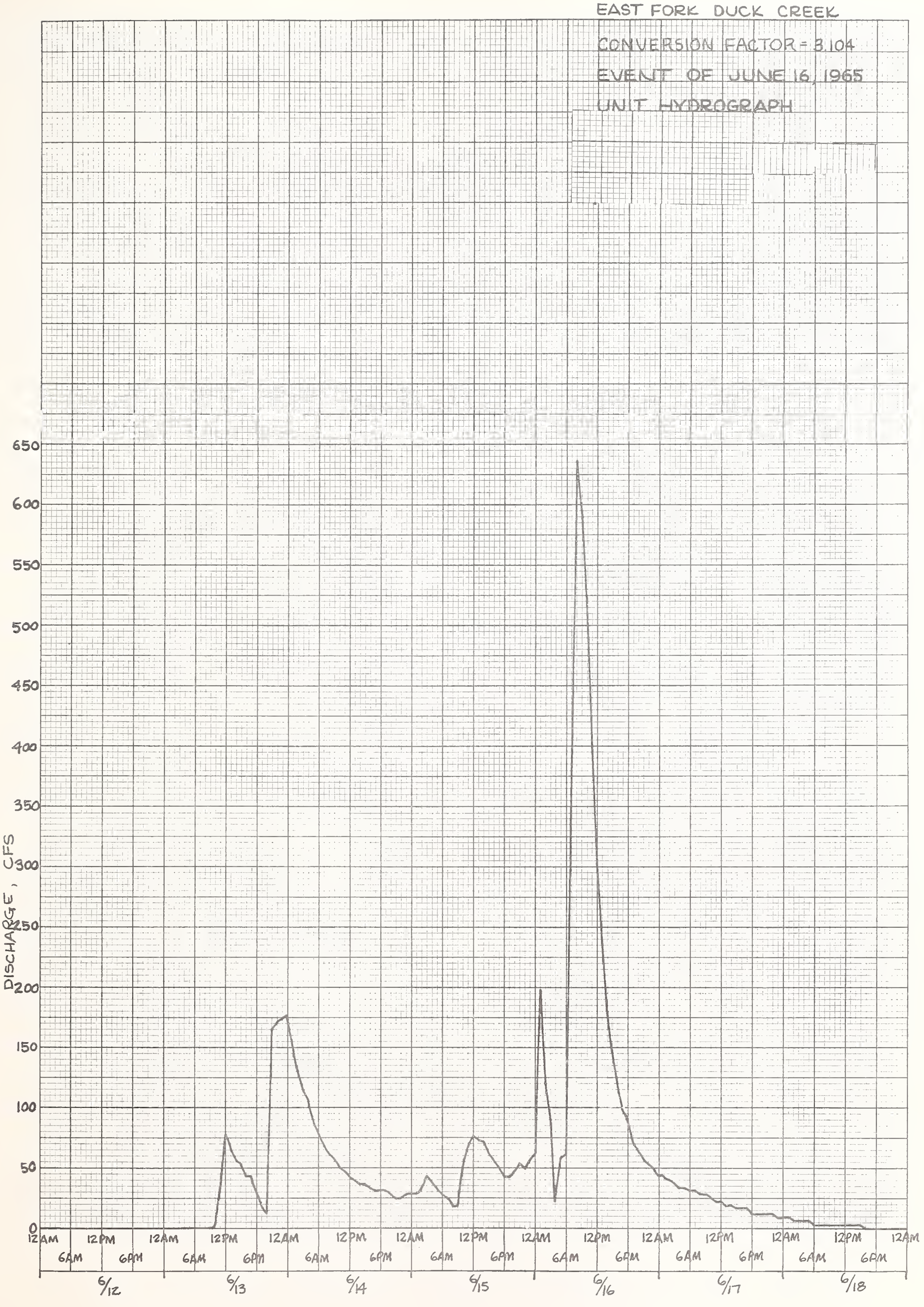
HAUK = 2.13"

JONAS = 1.91"

ALLEN = 2.07"

TOTAL RUNOFF = .04


E.F. DUCK CREEK
EVENT OF JUNE 16, 1965
PRECIPITATION, INCHES
0.56"
.3
.2
.1
0
JORDAN
TOTAL: 2.13
8 HOURS
NO RECORD
TOTAL:
SCHWAB
0.51"
UELAND
TOTAL: 2.30
15 HOURS
3.5 HOURS
NON-RECORDING RAIN GAGES
HAUK 4.30"
JONAS 4.10"
MEISSNER 3.31"
ALLEN 4.16"
RUNOFF = .3221
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
200
190
180
170
160
150
140
130
120
110
12AM
12PM
6/12
6/13
6/14
6/15
6/16
6/17
6/18
1965

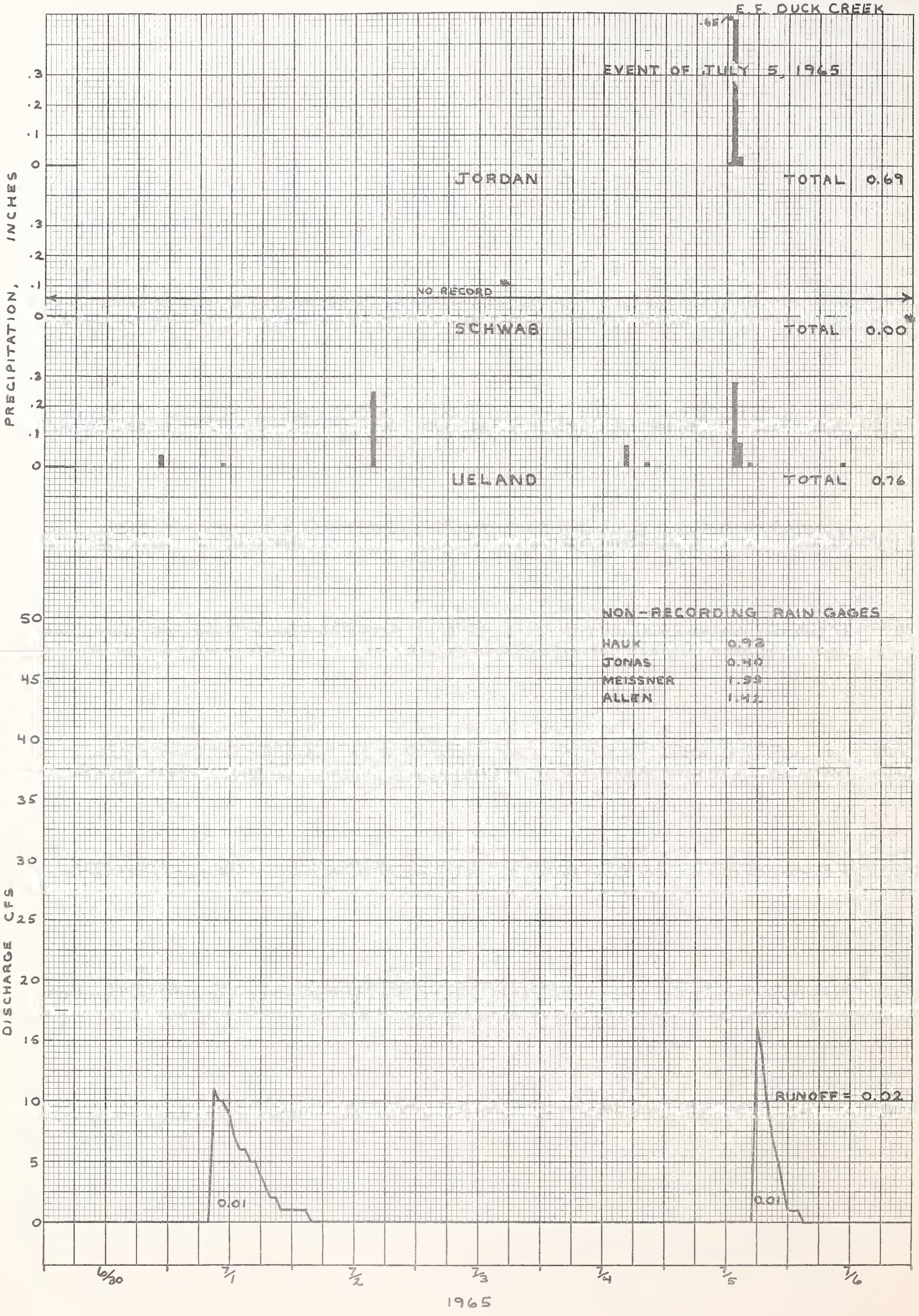


EAST FORK DUCK CREEK

CONVERSION FACTOR = 3.104

EVENT OF JUNE 16, 1965

UNIT HYDROGRAPH

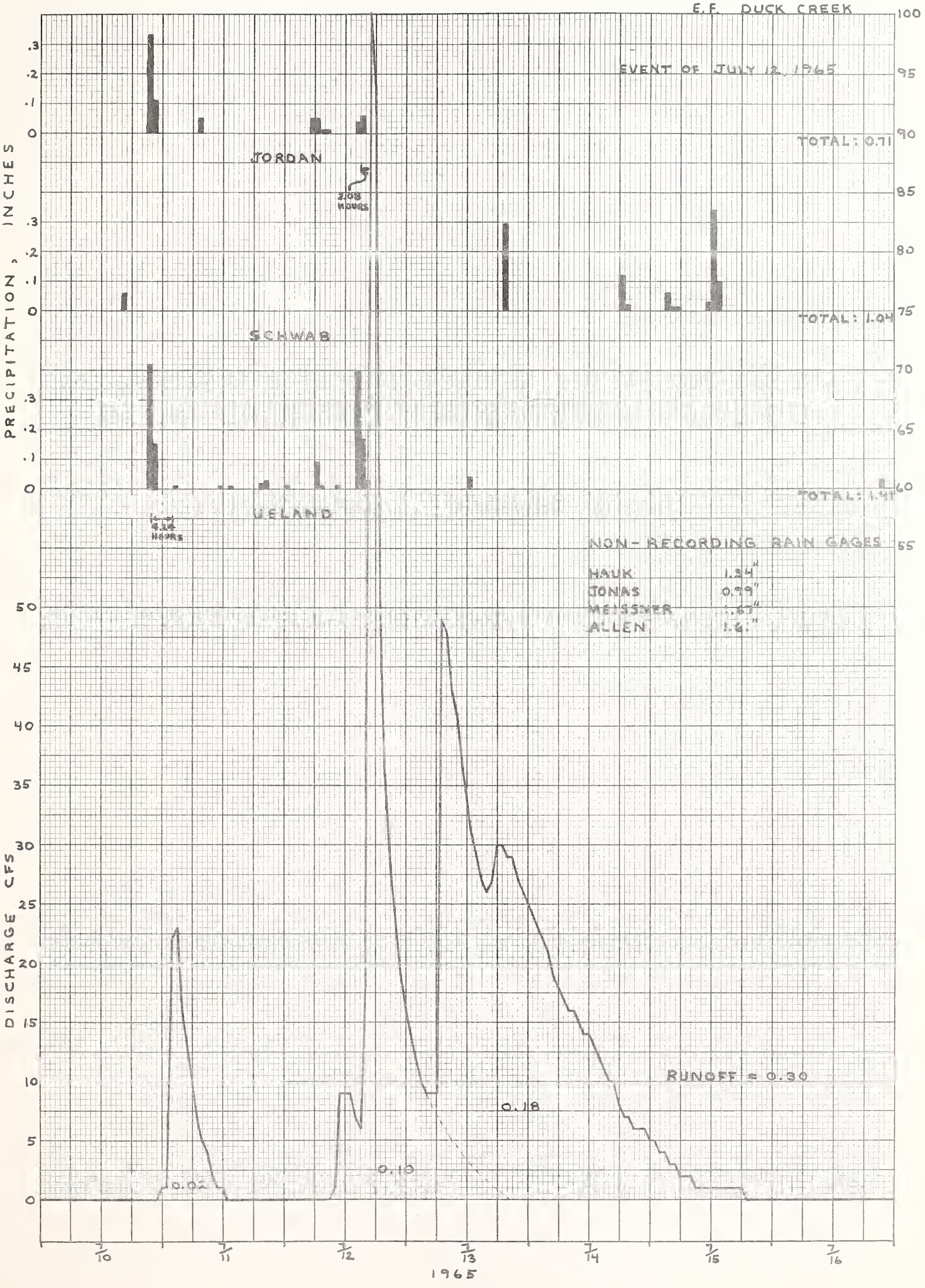


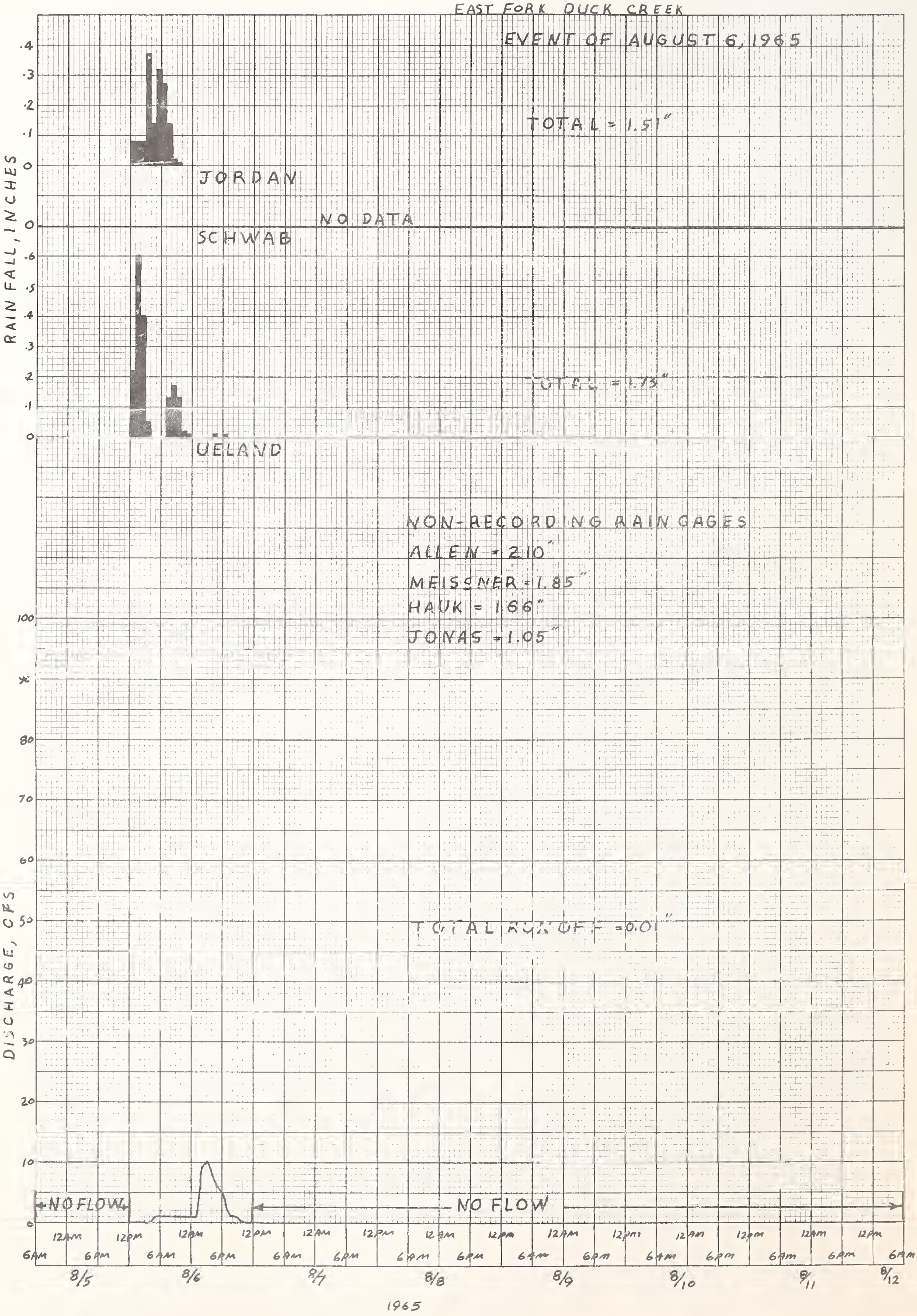
E.F. DUCK CREEK

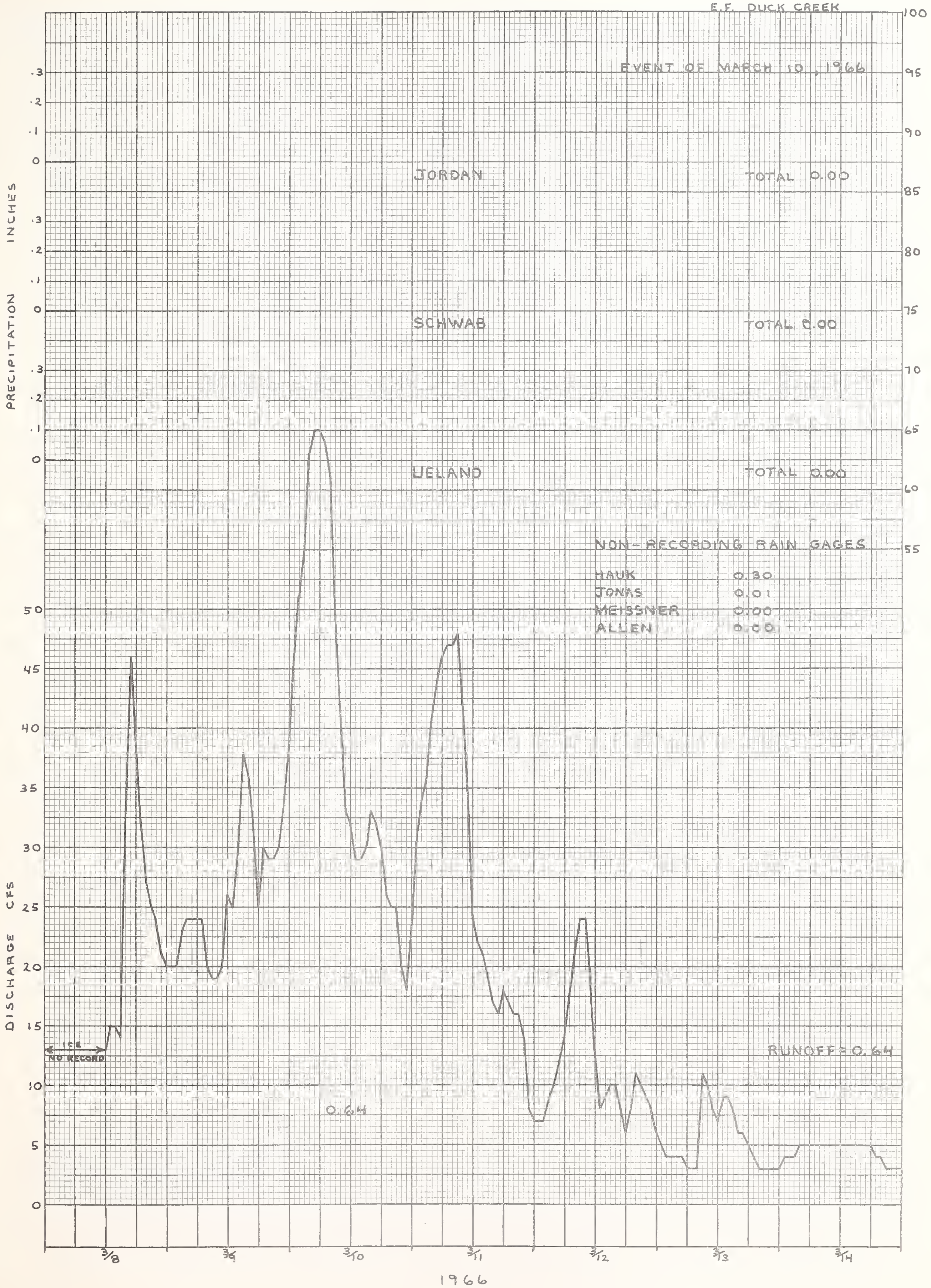
EVENT OF JULY 5, 1965

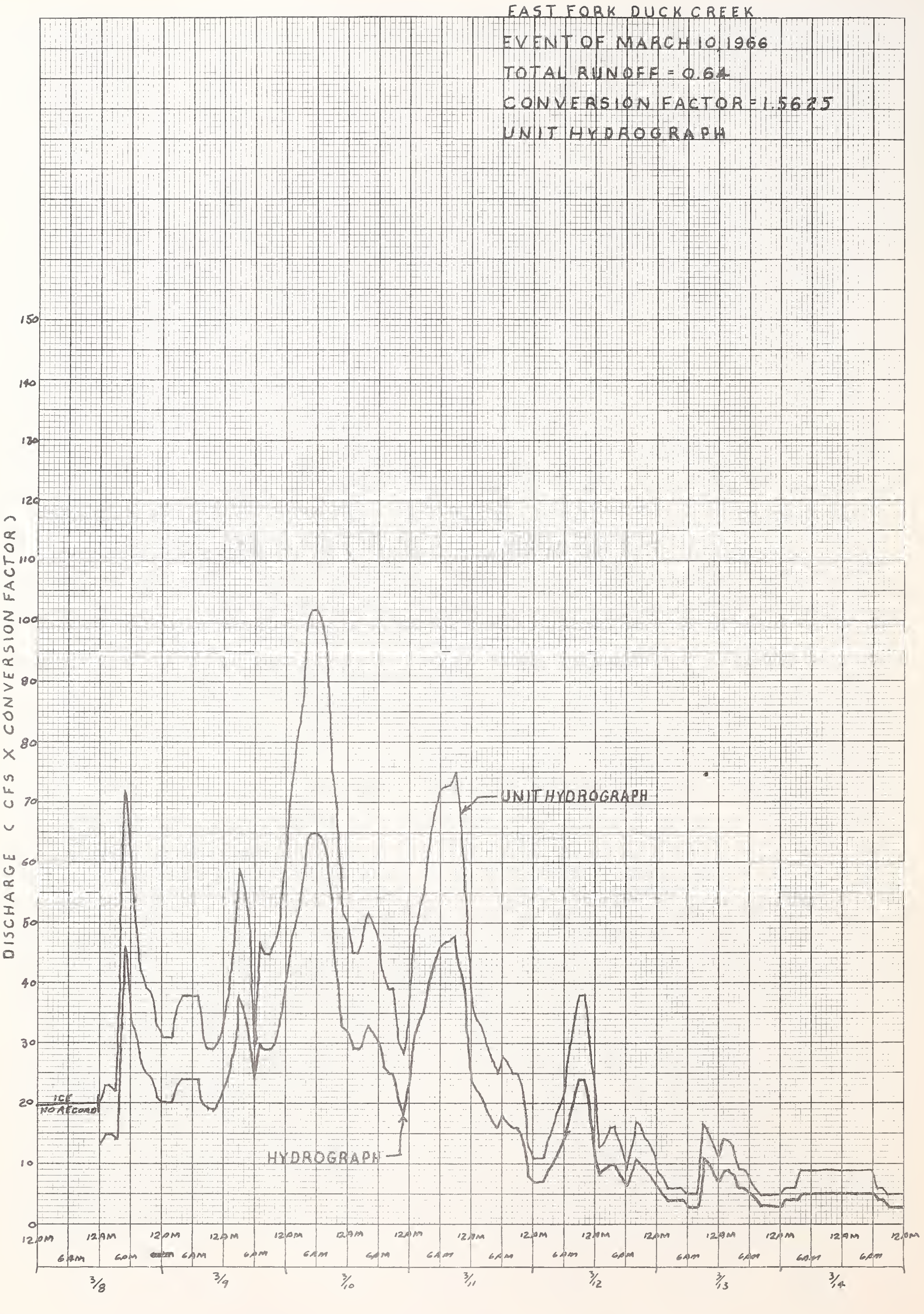
NON-RECORDING RAIN GAGES

HAUK	0.93
JONAS	0.40
MEISSNER	1.33
ALLEN	1.42

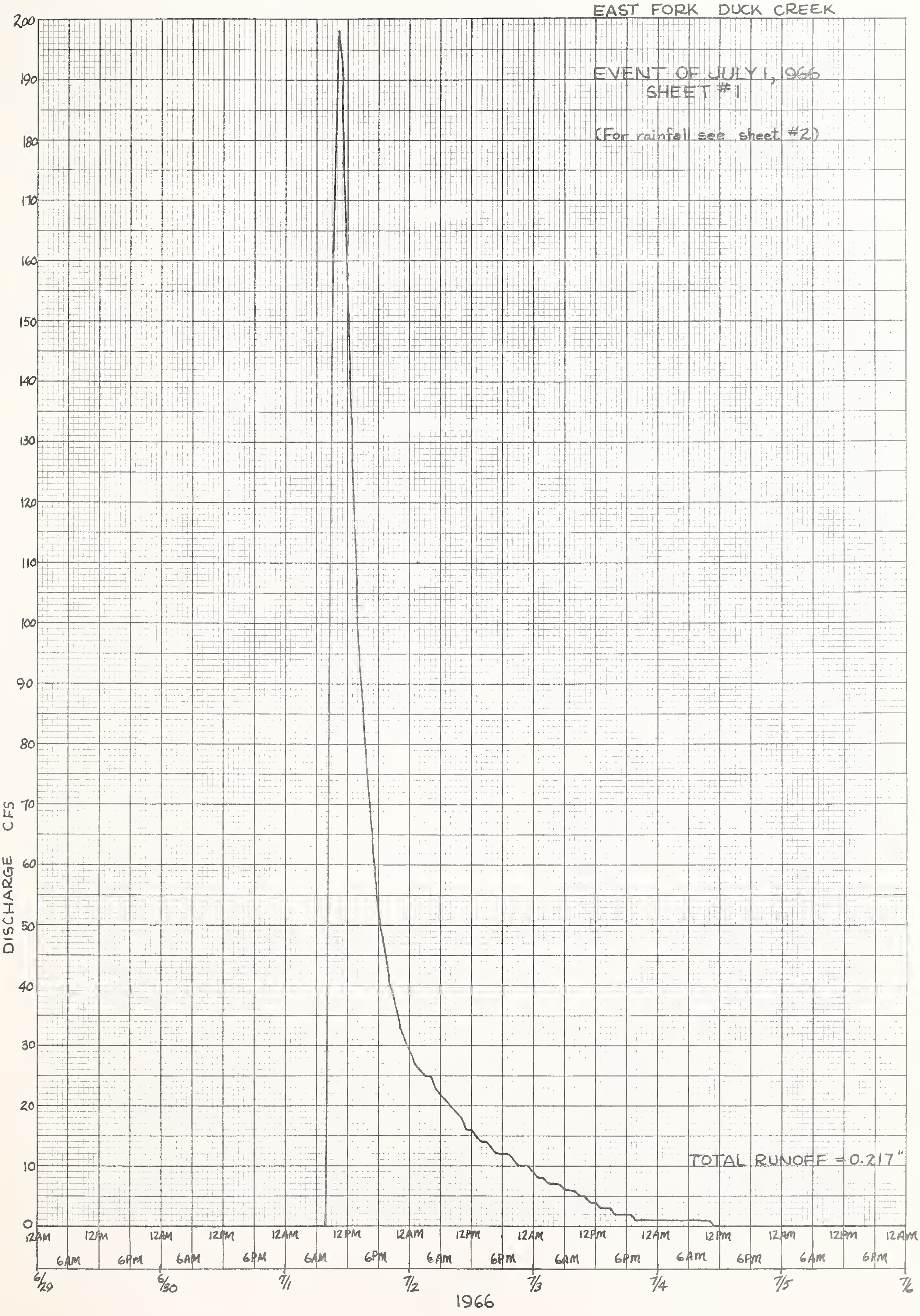
E.F. DUCK CREEK
EVENT OF JULY 12, 1965
PRECIPITATION, INCHES
.3
.2
.1
0
JORDAN
TOTAL: 0.71
2.08 HOURS
SCHWAB
TOTAL: 1.04
UELAND
TOTAL: 1.41
4.25 HOURS
NON-RECORDING RAIN GAGES
HAUK 1.34"
JONAS 0.99"
MEISSNER .67"
ALLEN 1.6"
DISCHARGE CFS
50
45
40
35
30
25
20
15
10
5
0
0.02
0.10
0.18
RUNOFF = 0.30
100
95
90
85
80
75
70
65
60
55
7/10
7/11
7/12
7/13
7/14
7/15
7/16
1965


EAST FORK DUCK CREEK
EVENT OF AUGUST 6, 1965
TOTAL = 1.51"
JORDAN
NO DATA
SCHWAB
TOTAL = 1.73"
UELAND
NON-RECORDING RAIN GAGES
ALLEN = 2.10"
MEISSNER = 1.85"
HAUK = 1.66"
JONAS = 1.05"
TOTAL RUNOFF = 0.01"
RAIN FALL, INCHES
.4
.3
.2
.1
0
0
.6
.5
.4
.3
.2
.1
0
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
NO FLOW
NO FLOW
12AM
12PM
6AM
6PM
8/5
8/6
8/7
8/8
8/9
8/10
8/11
8/12
1965

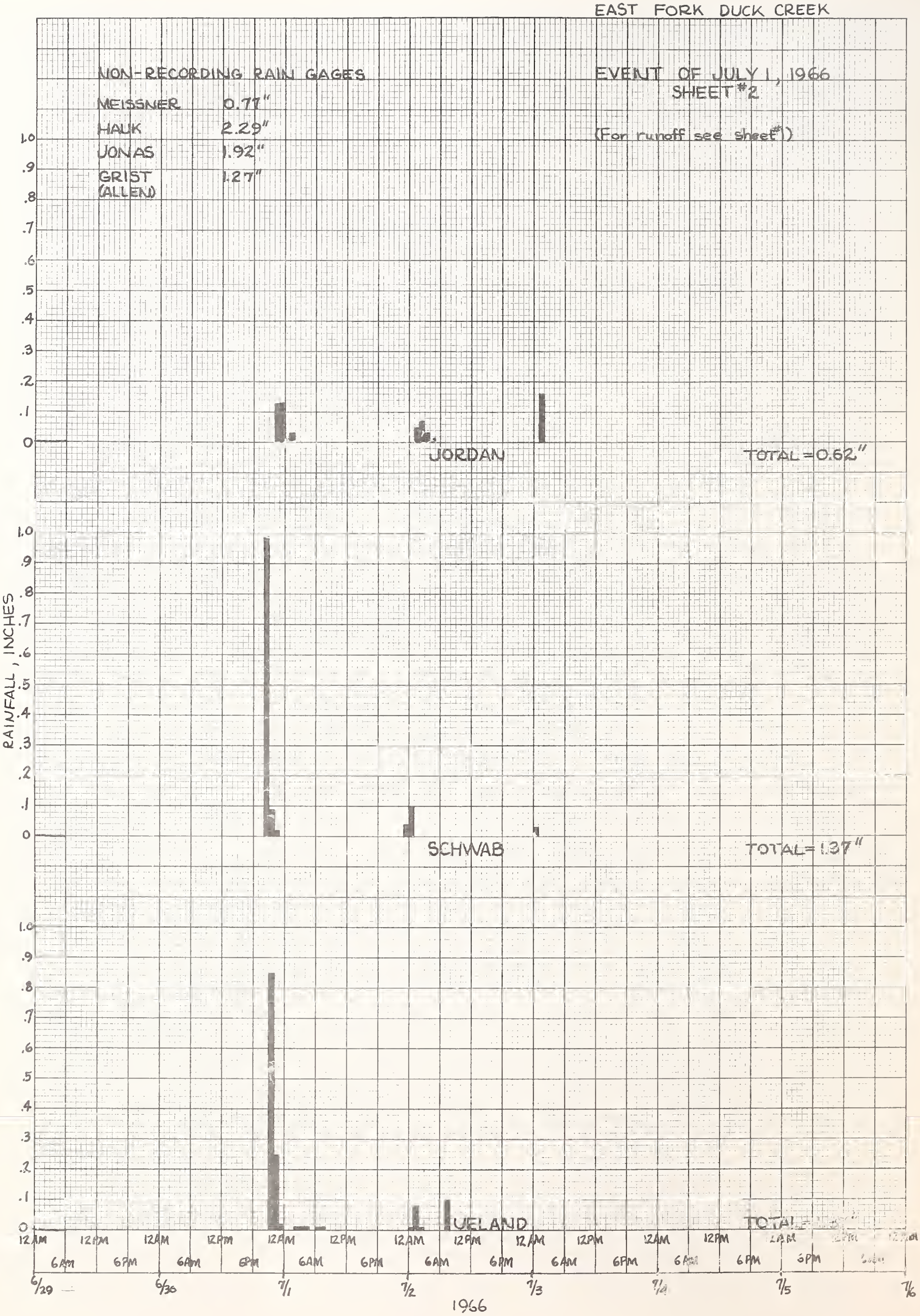

E.F. DUCK CREEK
EVENT OF MARCH 10, 1966
JORDAN
TOTAL 0.00
SCHWAB
TOTAL 0.00
UELAND
TOTAL 0.00
NON-RECORDING RAIN GAGES
HAUK 0.30
JONAS 0.01
MEISSNER 0.00
ALLEN 0.00
RUNOFF = 0.64
0.64
ICE
NO RECORD
PRECIPITATION INCHES
DISCHARGE CFS
.3
.2
.1
0
50
45
40
35
30
25
20
15
10
5
0
100
95
90
85
80
75
70
65
60
55
3/8
3/9
3/10
3/11
3/12
3/13
3/14
1966



EAST FORK DUCK CREEK
EVENT OF MARCH 10, 1966
TOTAL RUNOFF = 0.64
CONVERSION FACTOR = 1.5625
UNIT HYDROGRAPH


EAST FORK DUCK CREEK
EVENT OF JULY 1, 1966
SHEET #1
(For rainfall see sheet #2)
TOTAL RUNOFF = 0.217"
DISCHARGE CFS
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
12AM
12PM
6AM
6PM
6/29
6/30
7/1
7/2
7/3
7/4
7/5
7/6
1966

EAST FORK DUCK CREEK



EVENT OF JULY 1, 1966
SHEET #2

(For runoff see sheet #1)

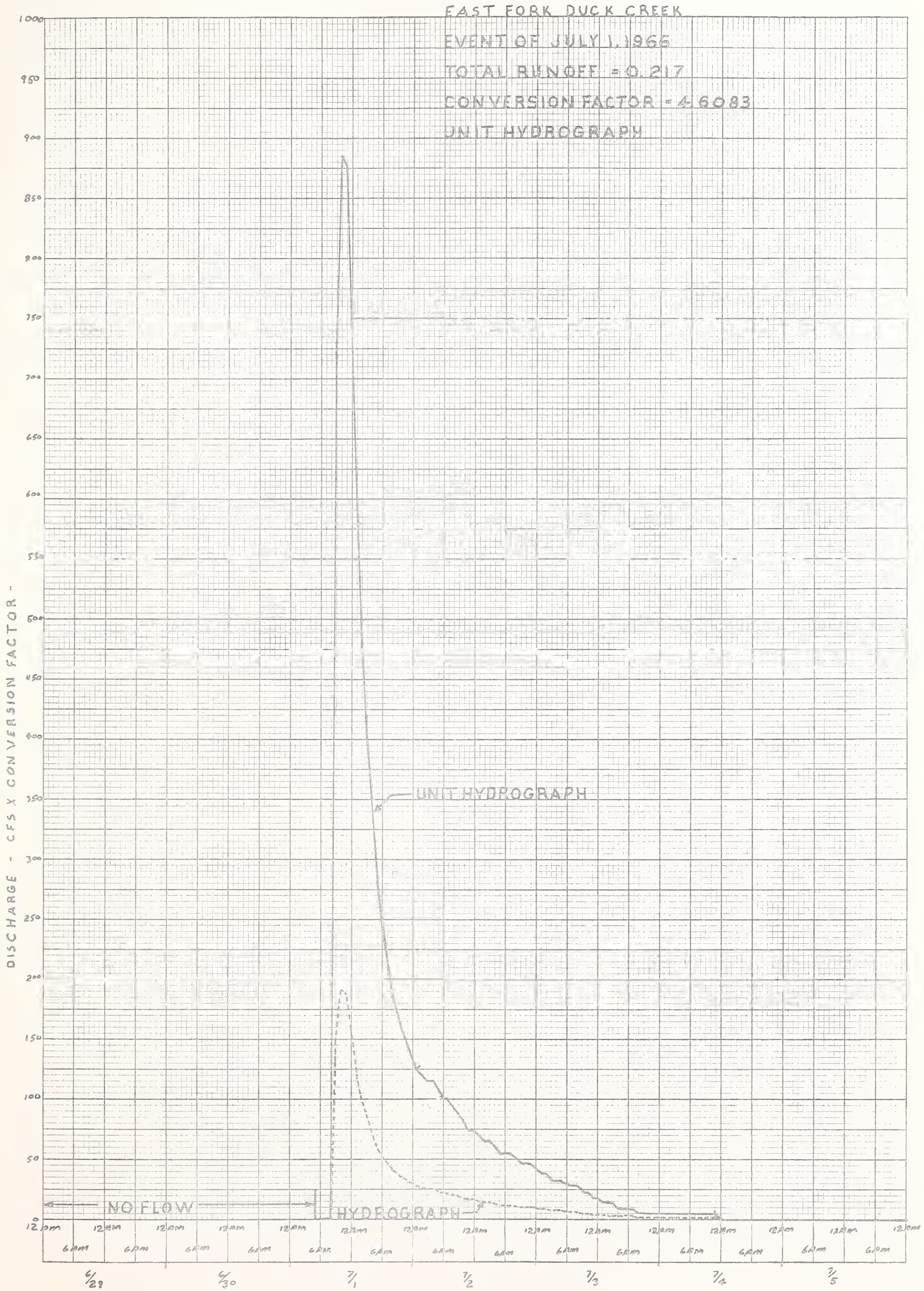
NON-RECORDING RAIN GAGES

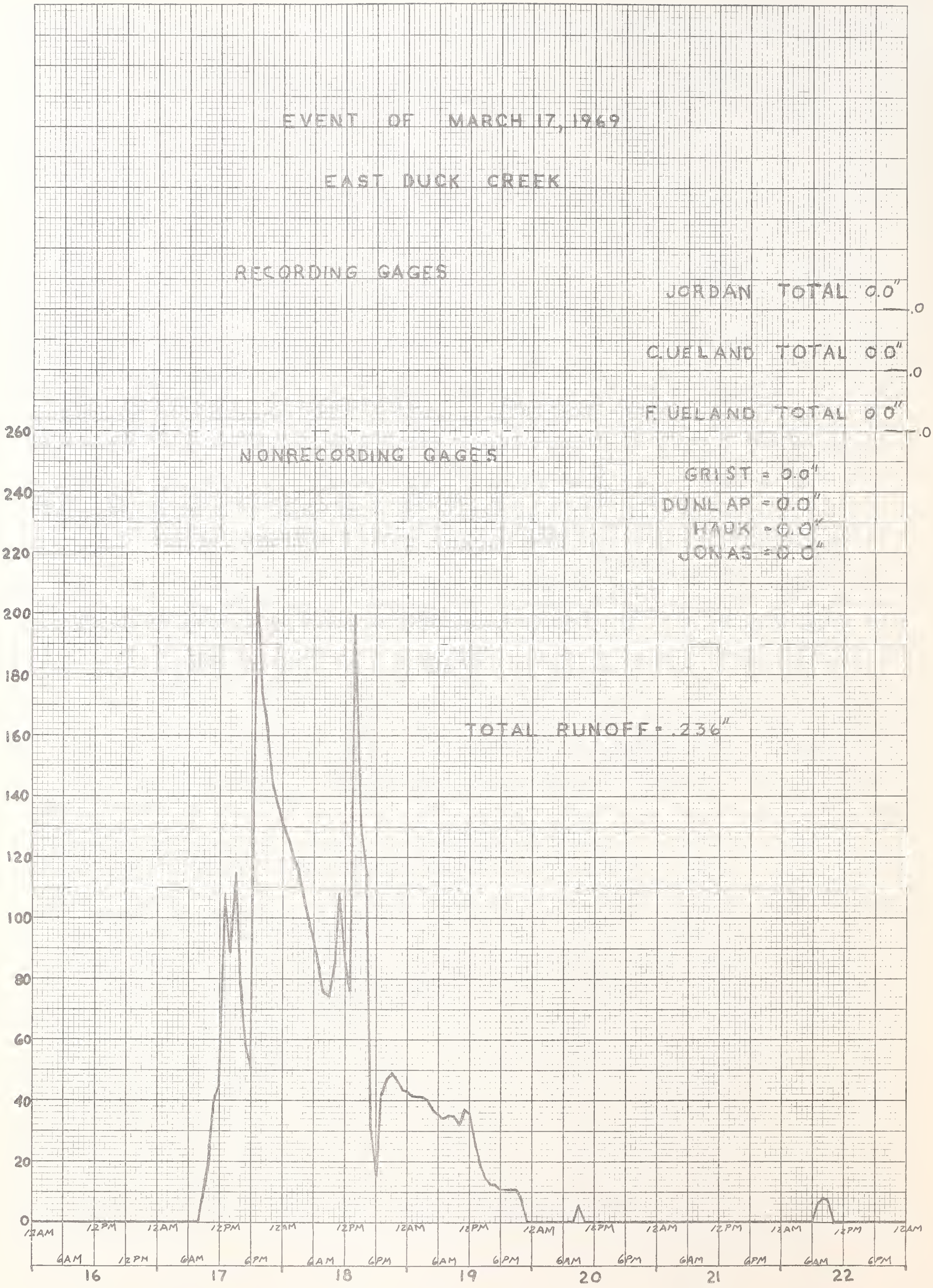
MEISSNER	0.71"
HAUK	2.29"
JONAS	1.92"
GRIST (ALLEN)	1.27"

JORDAN TOTAL = 0.62"

SCHWAB TOTAL = 1.37"

UELAND TOTAL = [illegible]


EAST FORK DUCK CREEK
EVENT OF JULY 1, 1966
TOTAL RUNOFF = 0.217
CONVERSION FACTOR = 4.6083
UNIT HYDROGRAPH
UNIT HYDROGRAPH
NO FLOW
HYDROGRAPH
DISCHARGE - CFS x CONVERSION FACTOR -
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6/29
6/30
7/1
7/2
7/3
7/4
7/5



EVENT OF MARCH 17, 1969

EAST DUCK CREEK

RECORDING GAGES

JORDAN TOTAL 0.0"

C. UELAND TOTAL 0.0"

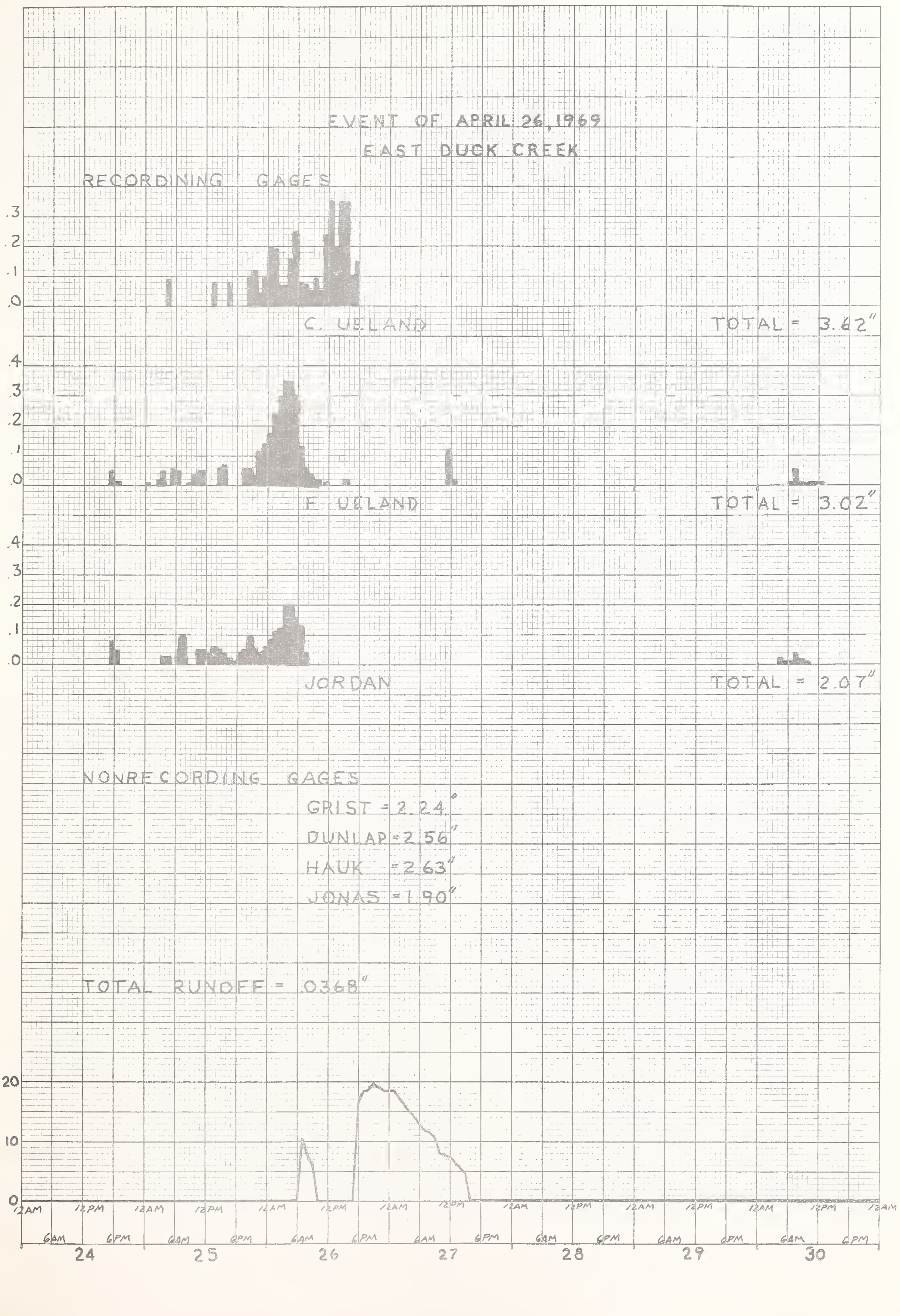
F. UELAND TOTAL 0.0"

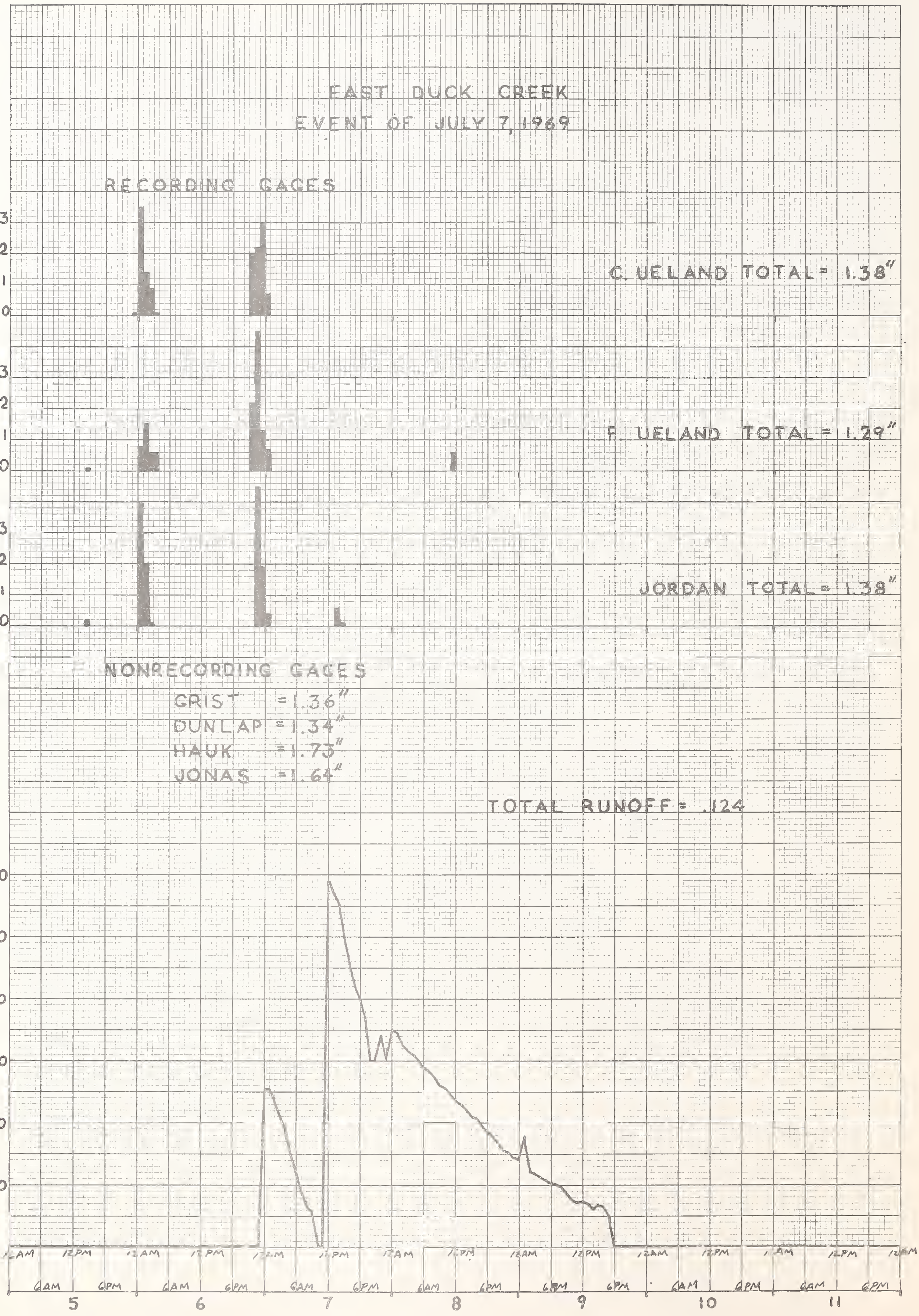
NONRECORDING GAGES

GRIST = 0.0"
DUNLAP = 0.0"
HAUK = 0.0"
JONAS = 0.0"

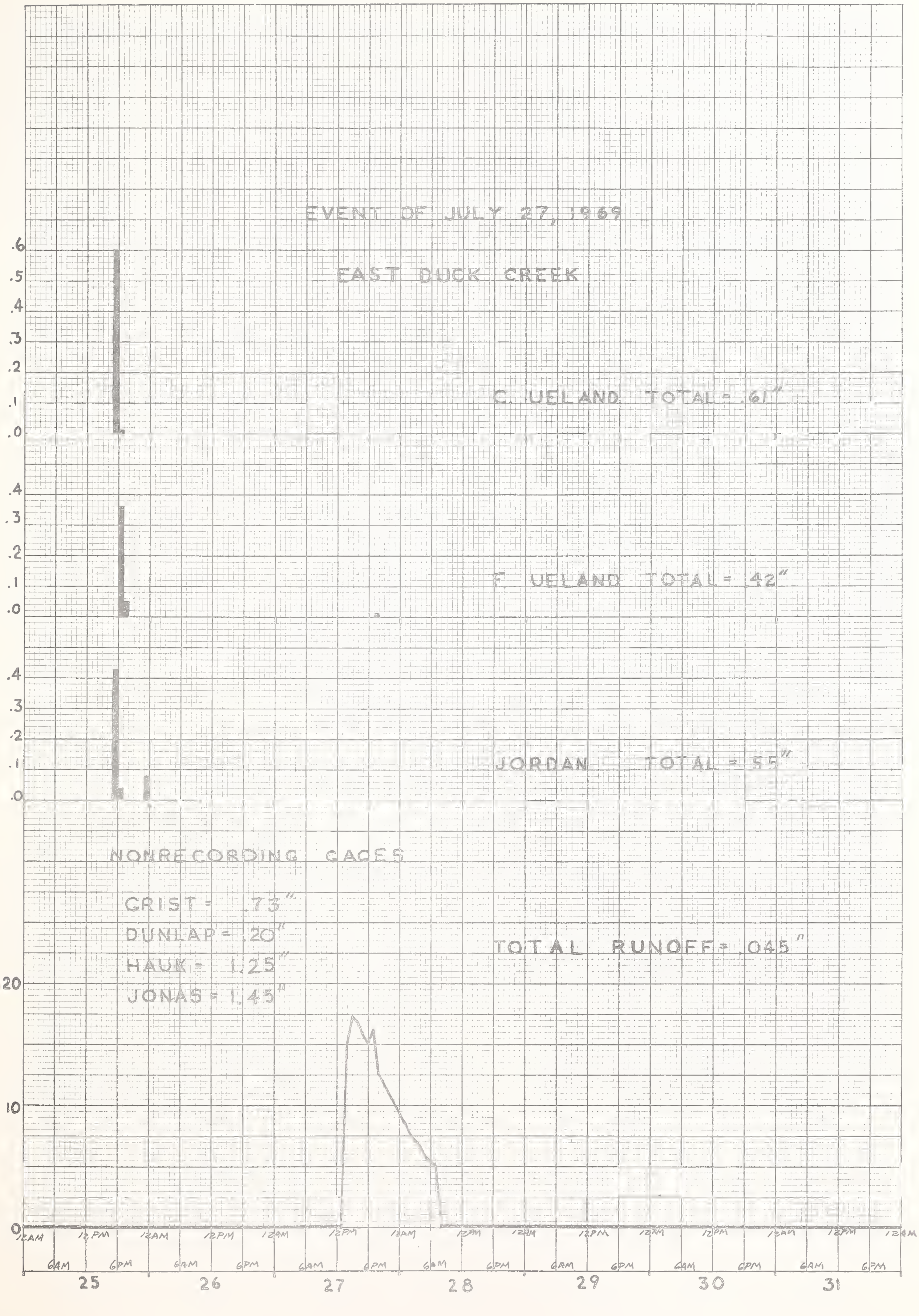
TOTAL RUNOFF = .236"

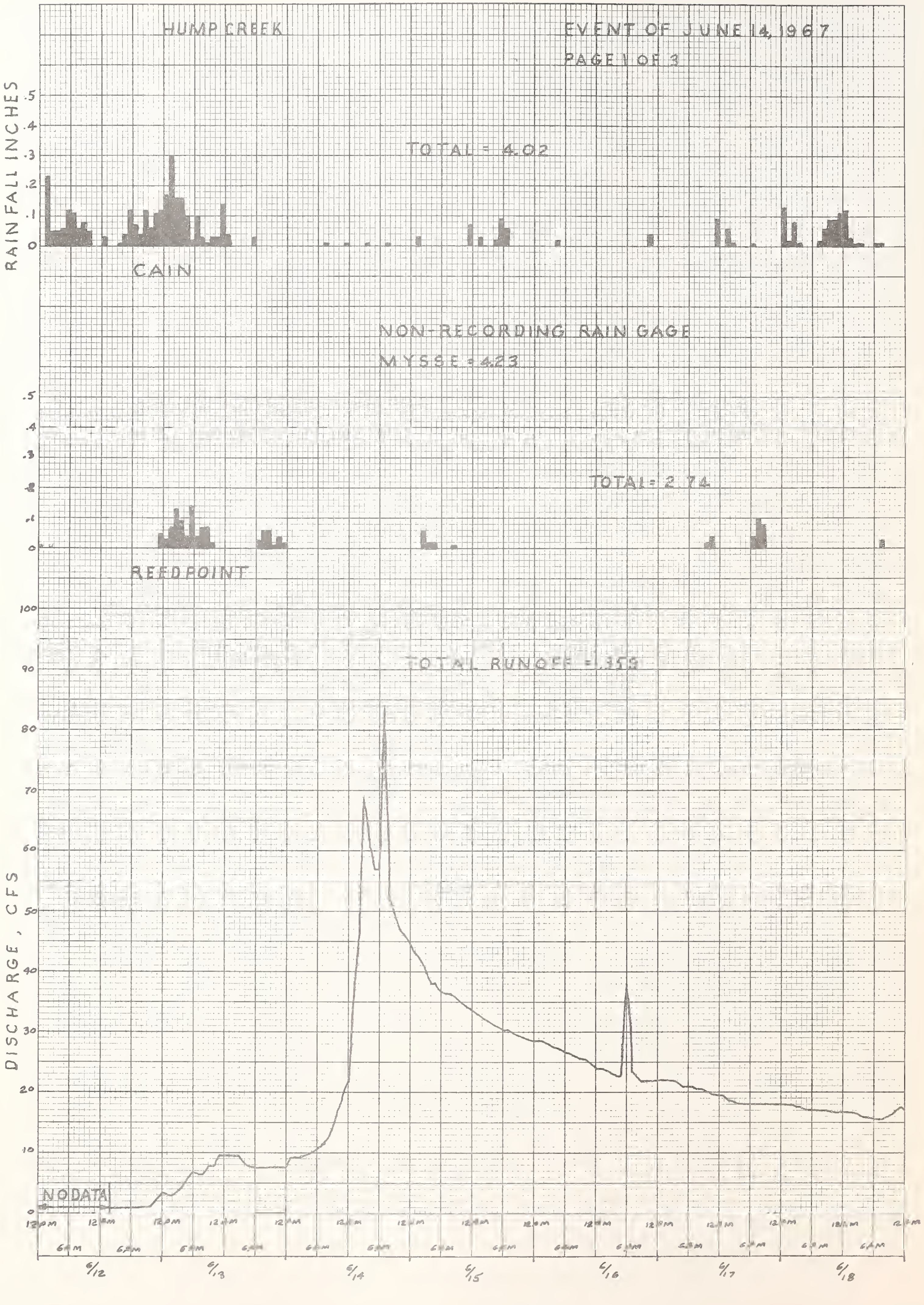
EVENT OF APRIL 26, 1969
EAST DUCK CREEK

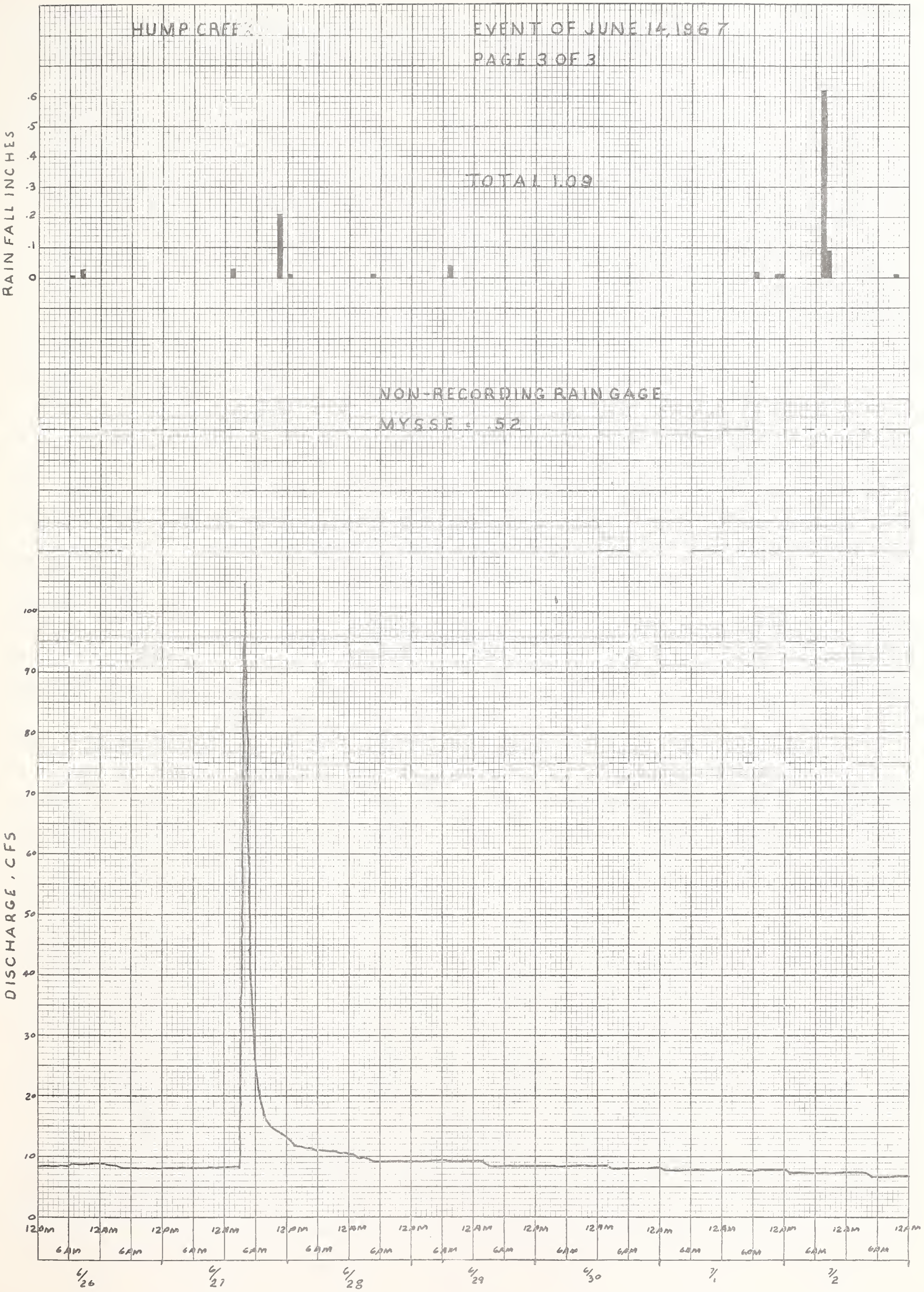


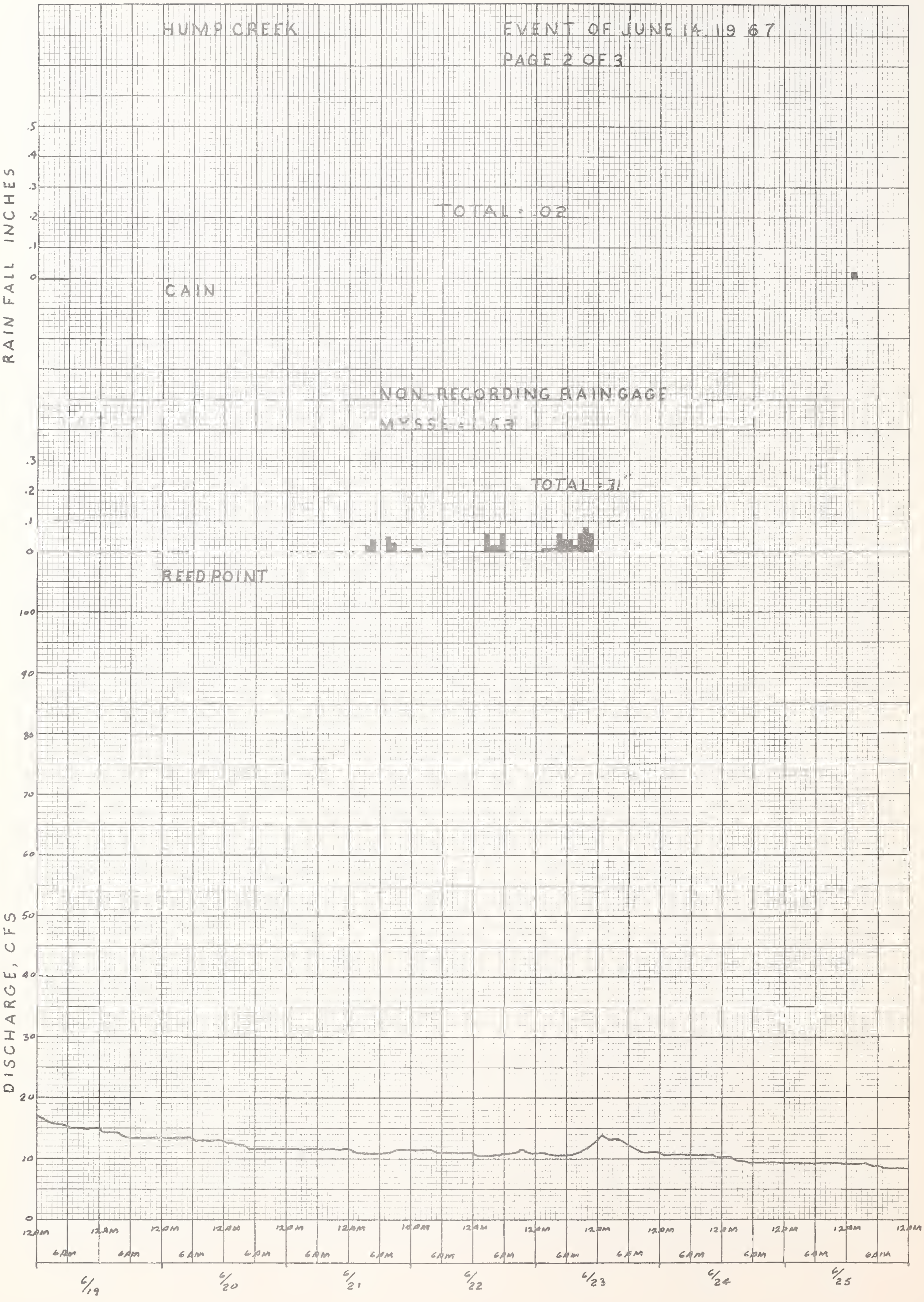


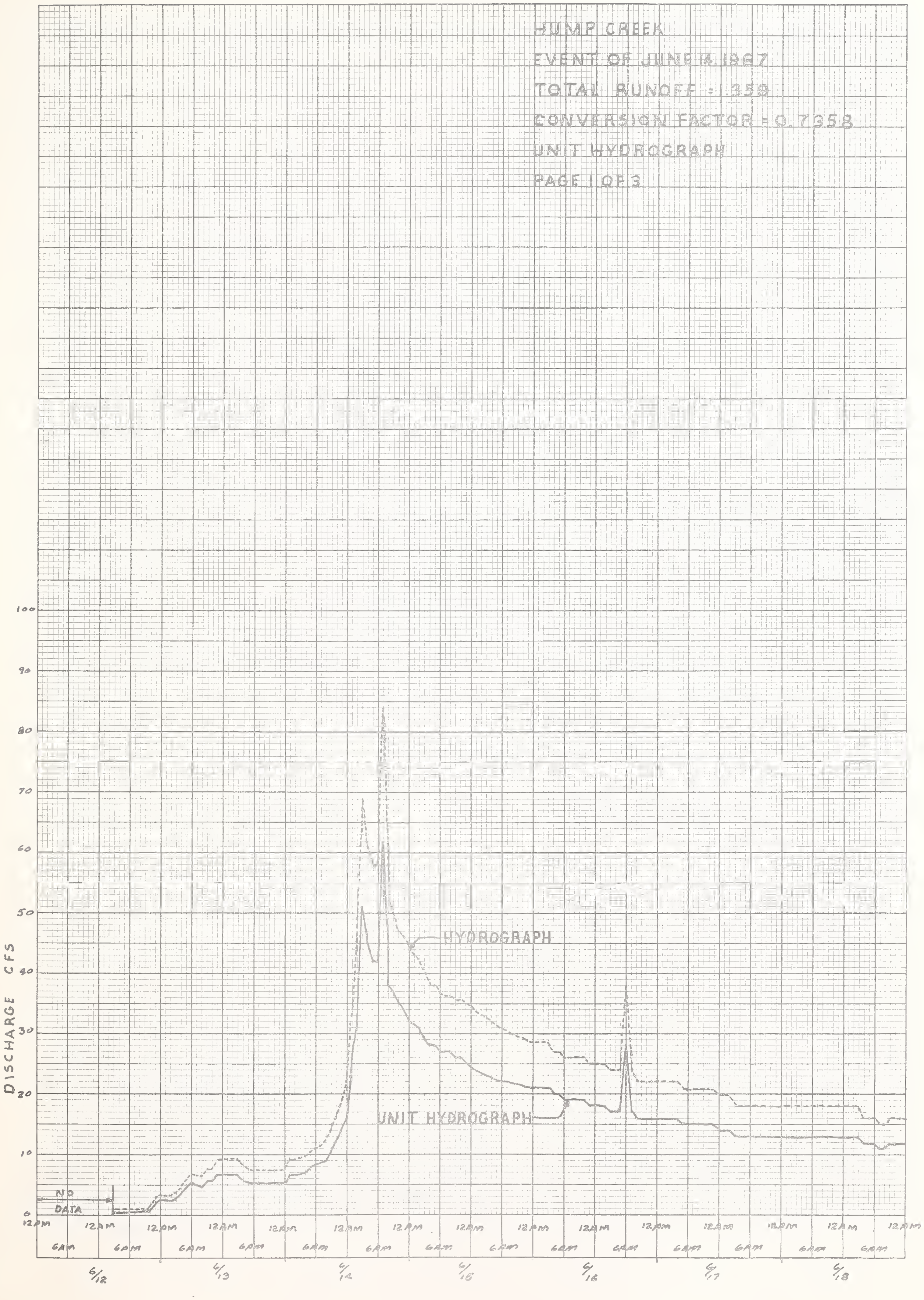
EAST DUCK CREEK
EVENT OF JULY 7, 1969


EVENT OF JULY 27, 1969
EAST DUCK CREEK
.6
.5
.4
.3
.2
.1
.0
C. UELAND TOTAL = .61"
.4
.3
.2
.1
.0
F. UELAND TOTAL = .42"
.4
.3
.2
.1
.0
JORDAN TOTAL = .55"
NONRECORDING GAGES
GRIST = .73"
DUNLAP = .20"
HAUK = 1.25"
JONAS = 1.45"
TOTAL RUNOFF = .045"
20
10
0
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
25
26
27
28
29
30
31

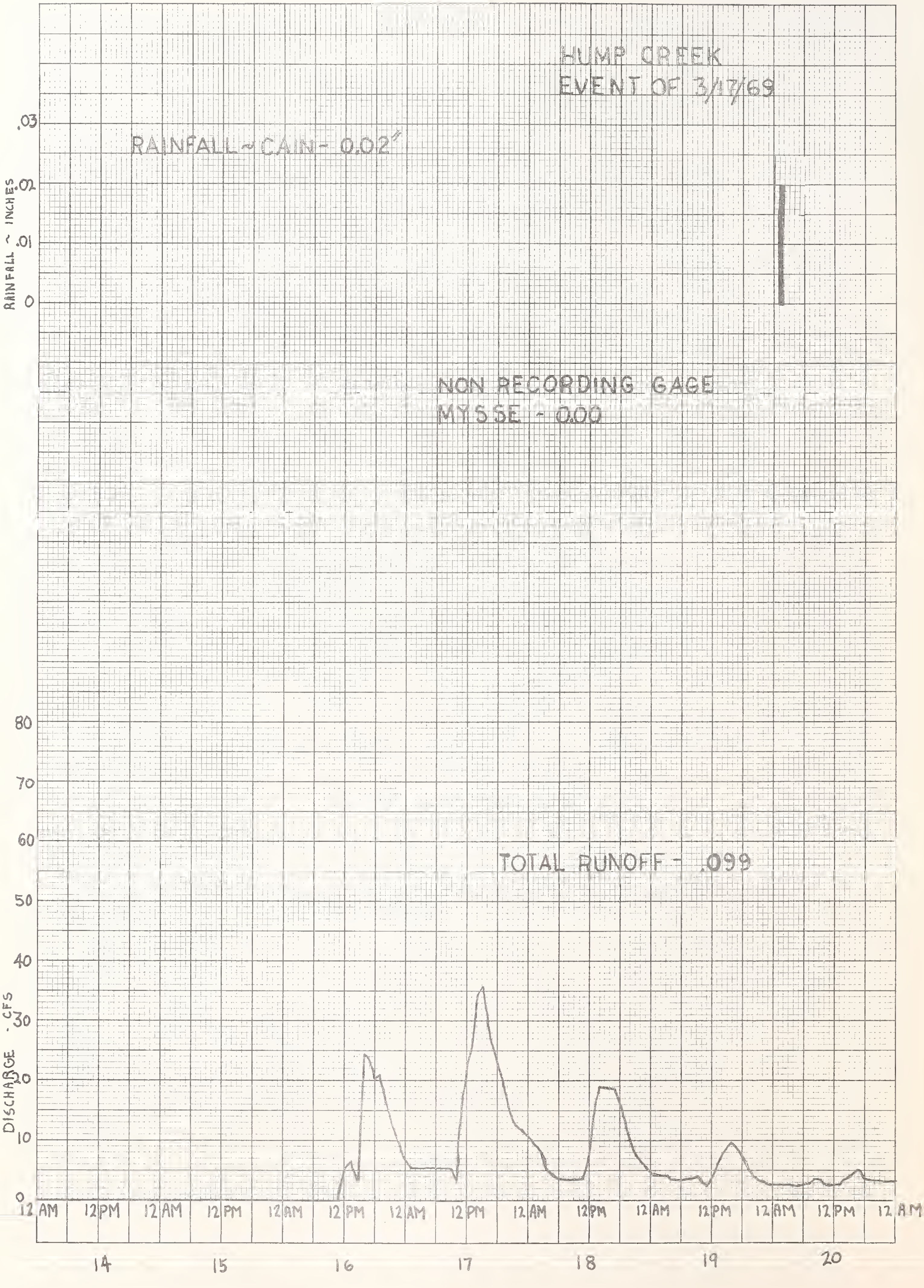

HUMP CREEK
EVENT OF JUNE 14, 1967
PAGE 1 OF 3
RAINFALL INCHES
.5
.4
.3
.2
.1
0
TOTAL = 4.02
CAIN
NON-RECORDING RAIN GAGE
MYSSE = 4.23
TOTAL = 2.74
REEDPOINT
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF = .359
NO DATA
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6/12
6/13
6/14
6/15
6/16
6/17
6/18

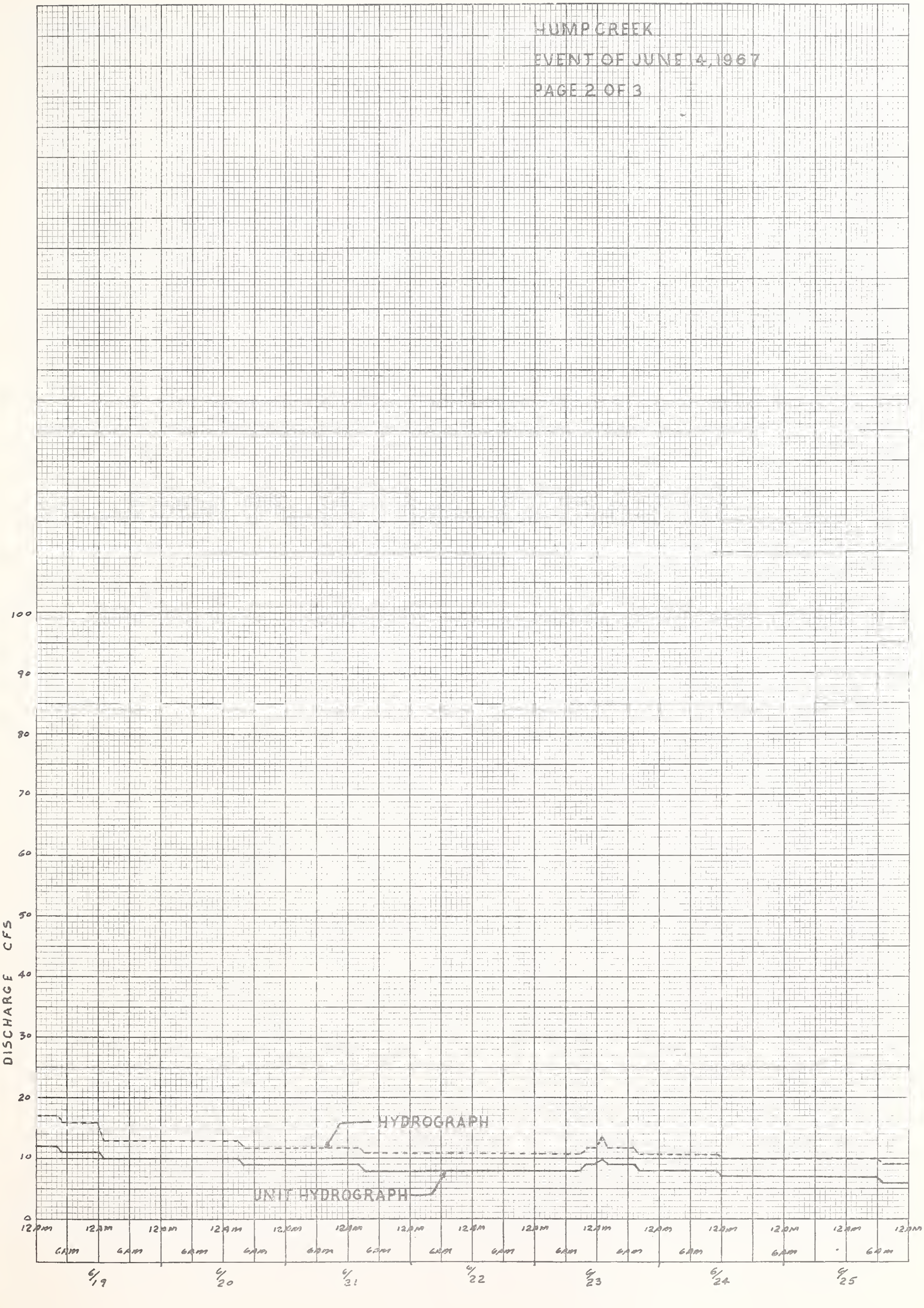

HUMP CREE
EVENT OF JUNE 14, 1967
PAGE 3 OF 3
RAIN FALL INCHES
.6
.5
.4
.3
.2
.1
0
TOTAL 1.09
NON-RECORDING RAIN GAGE
MYSSE = .52
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
12PM
6AM
12AM
6AM
12PM
6AM
12AM
6AM
12PM
6AM
12AM
6PM
12PM
6AM
12AM
6PM
12PM
6AM
12AM
6PM
12AM
6PM
12AM
6PM
12PM
6AM
12AM
6PM
12PM
6/26
6/27
6/28
6/29
6/30
7/1
7/2

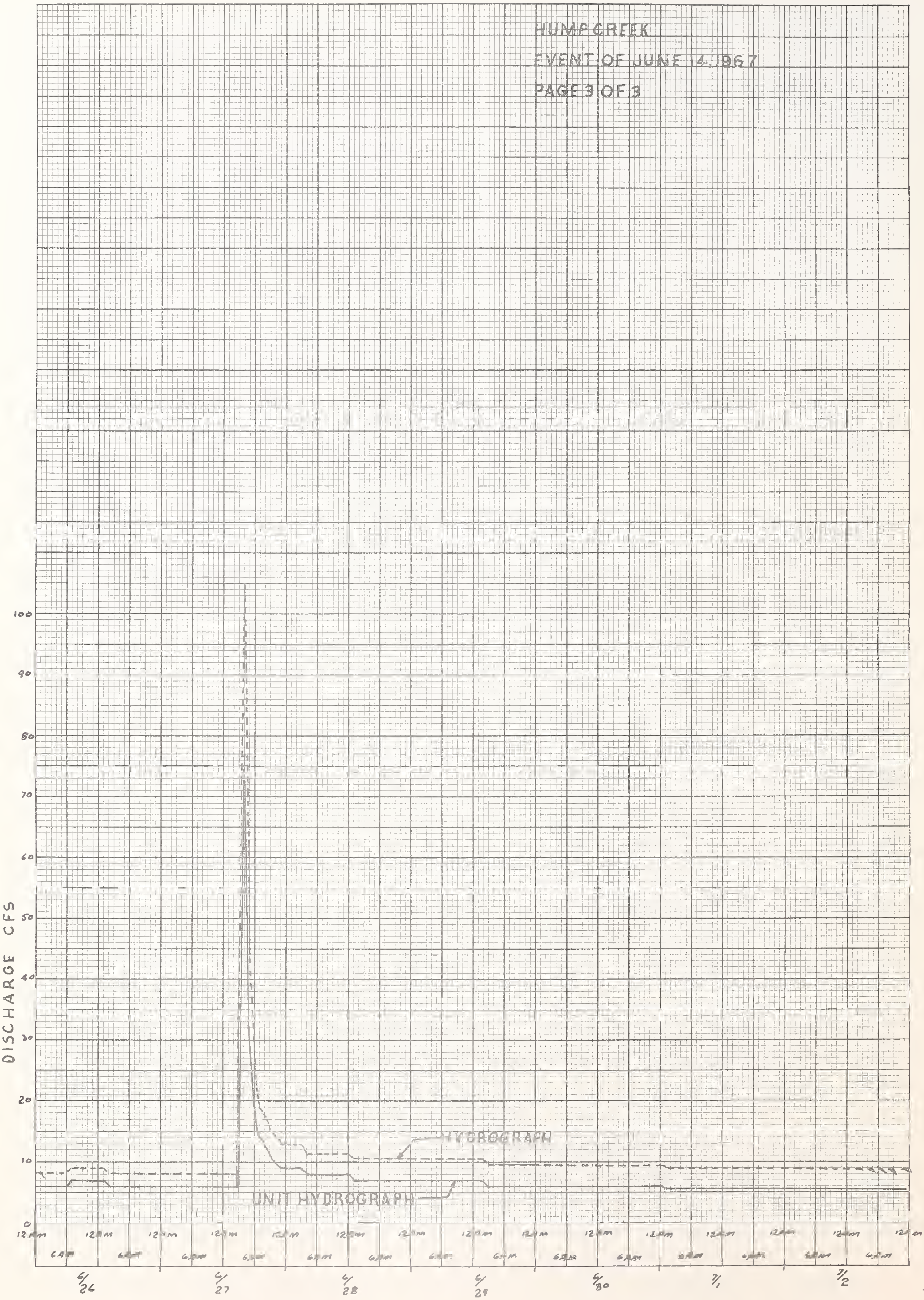
HUMP CREEK
EVENT OF JUNE 14, 1967
PAGE 2 OF 3
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
TOTAL = .02
CAIN
NON-RECORDING RAINGAGE
MYSSE = .53
.3
.2
.1
0
TOTAL = .71"
REED POINT
100
90
80
70
60
50
40
30
20
10
0
DISCHARGE, CFS
12AM
6AM
12PM
6PM
6/19
6/20
6/21
6/22
6/23
6/24
6/25

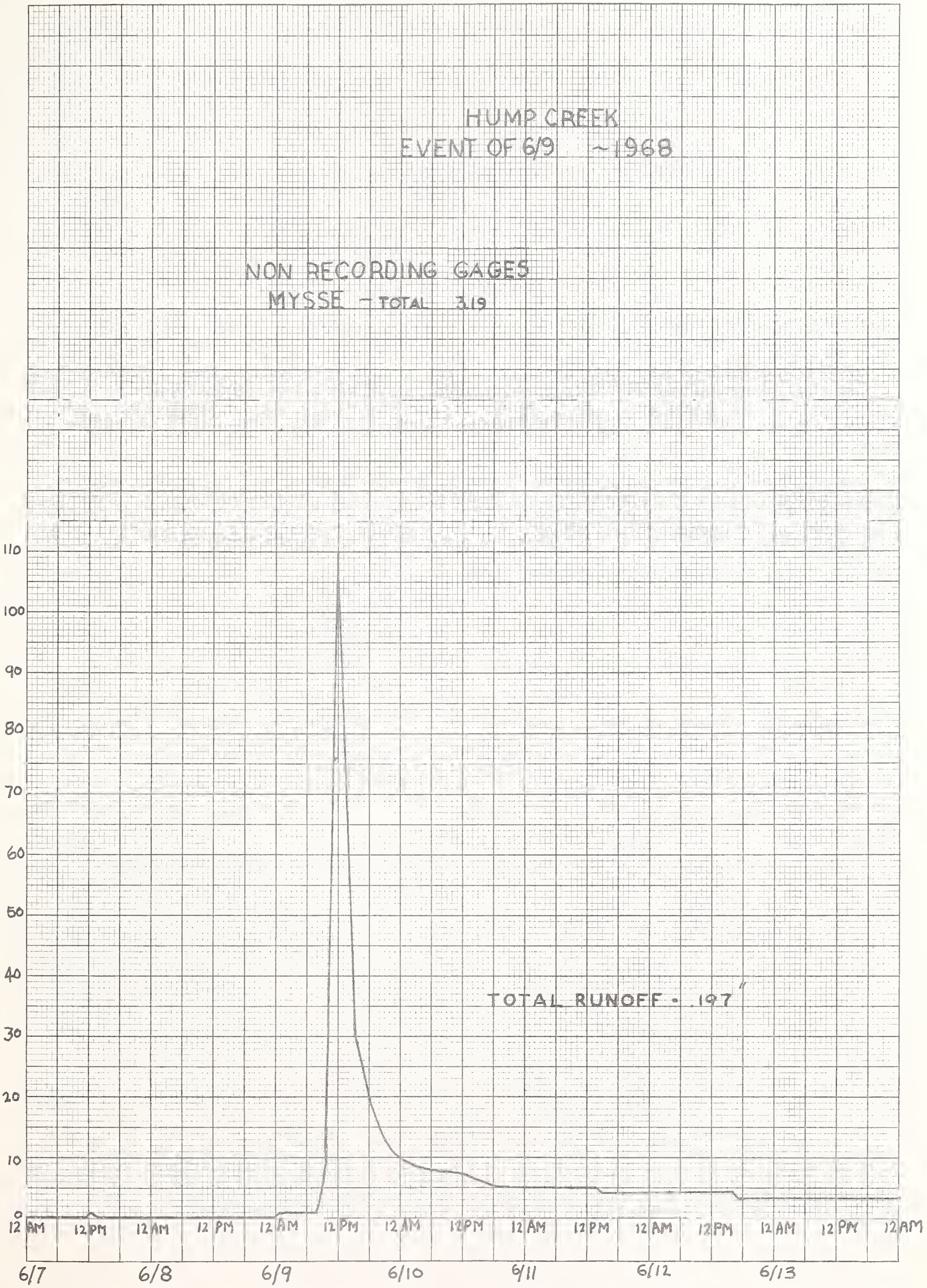


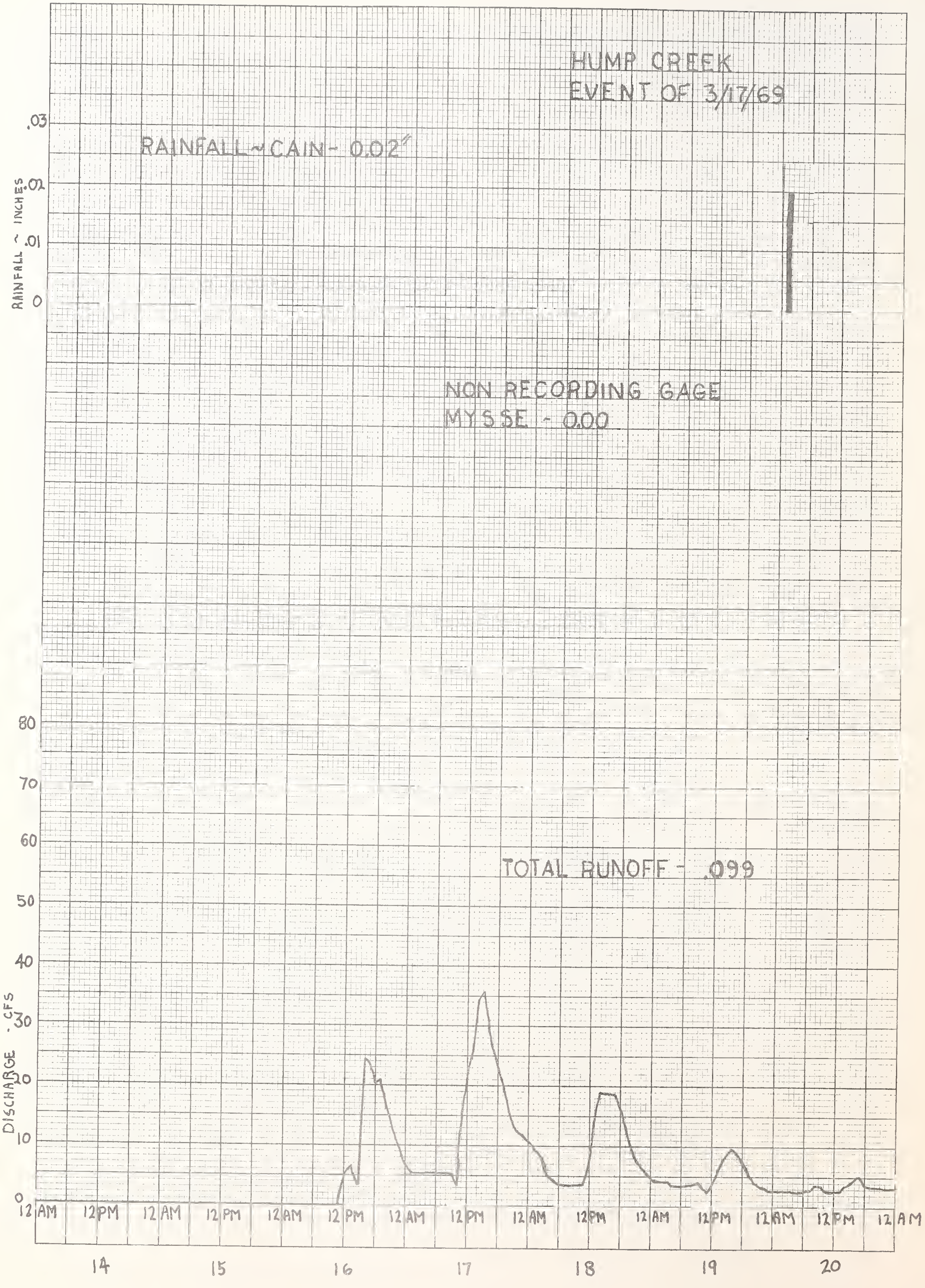
HUMP CREEK
EVENT OF JUNE 14, 1967
TOTAL RUNOFF = 1.359
CONVERSION FACTOR = 0.7358
UNIT HYDROGRAPH
PAGE 1 OF 3

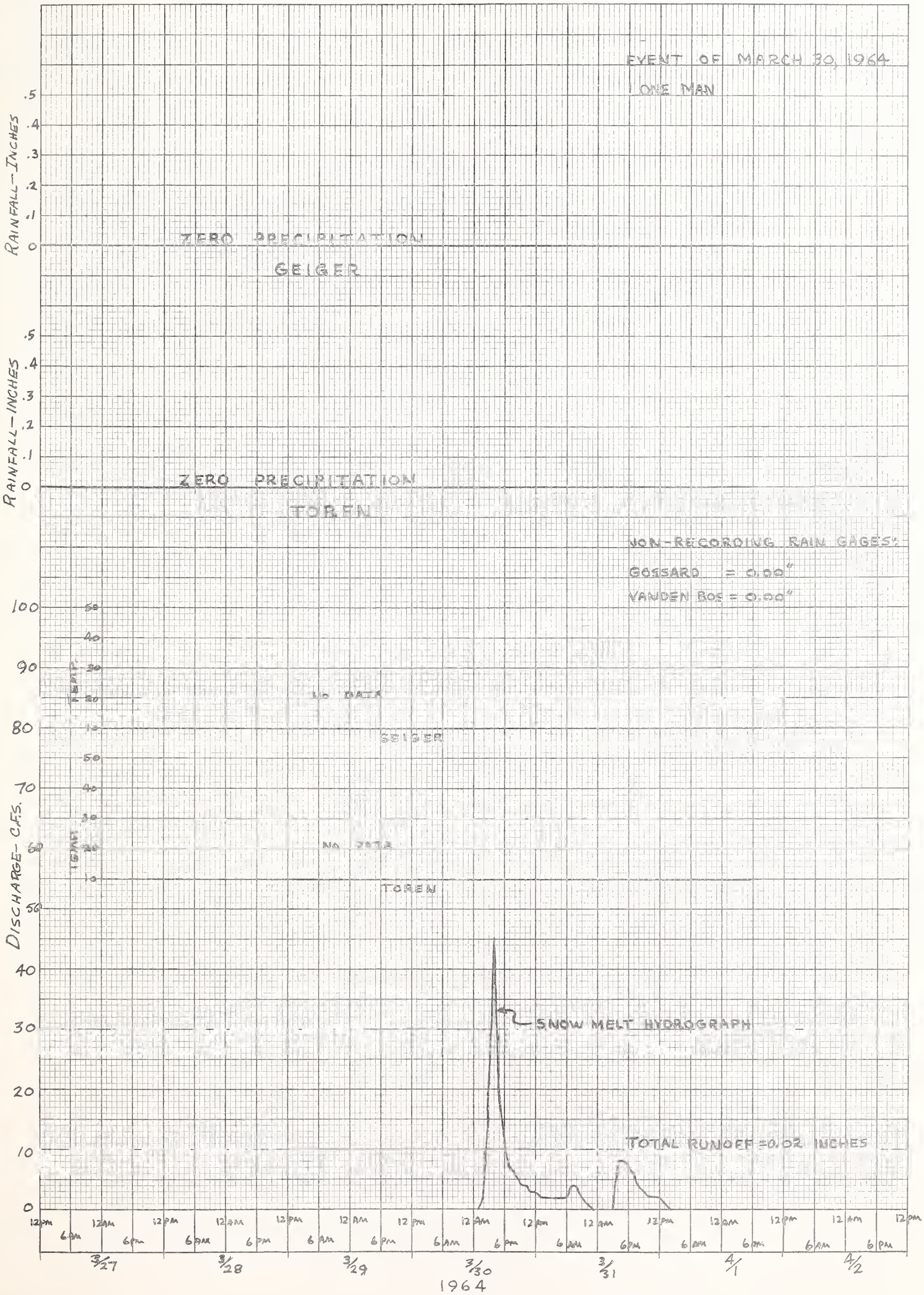

HUMP CREEK
EVENT OF 3/17/69
RAINFALL ~ CAIN - 0.02"
RAINFALL ~ INCHES
.03
.02
.01
0
NON RECORDING GAGE
MYSSE - 0.00
TOTAL RUNOFF - .099
DISCHARGE - CFS
80
70
60
50
40
30
20
10
0
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
14
15
16
17
18
19
20

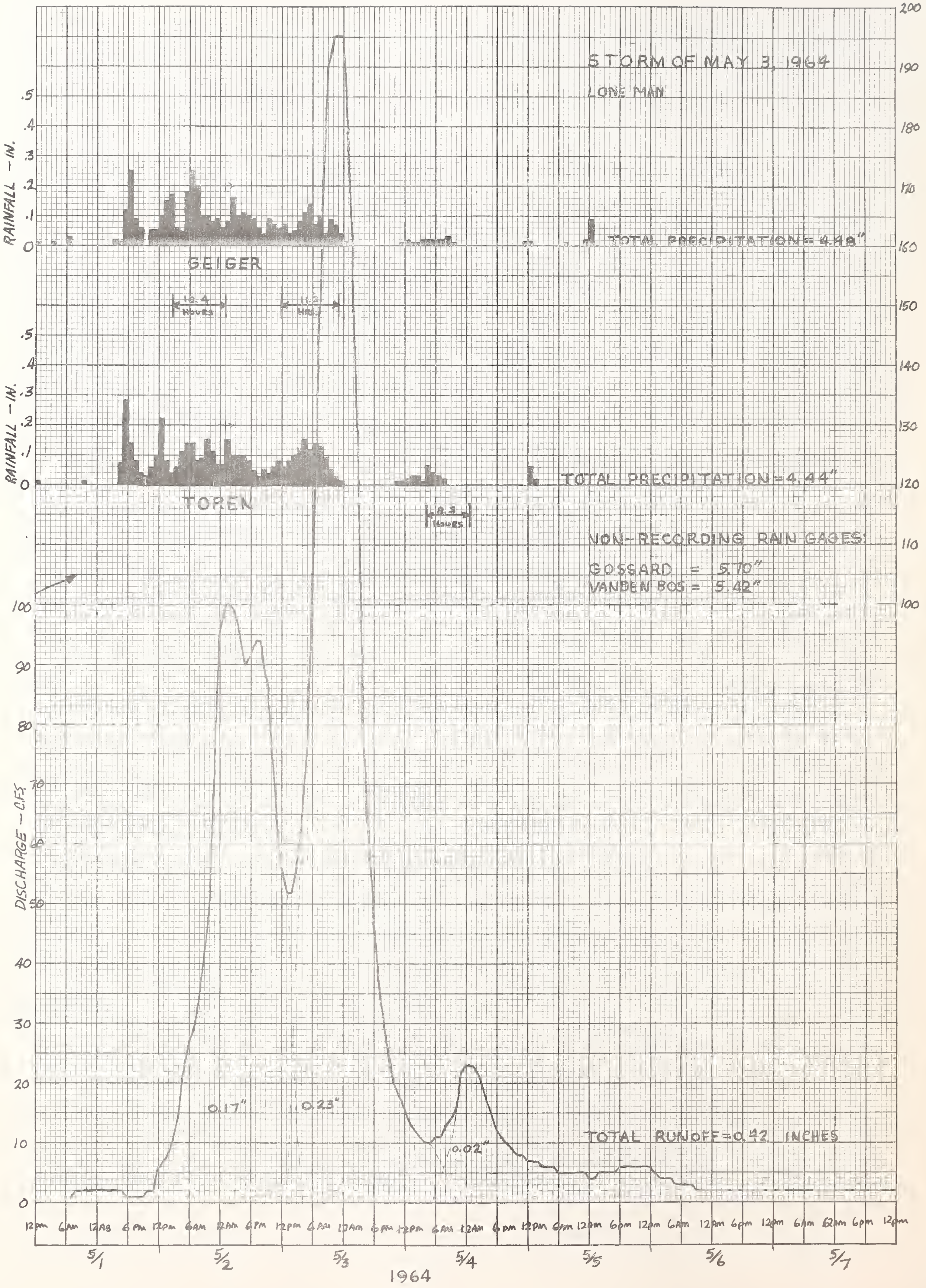

HUMP CREEK
EVENT OF JUNE 14, 1967
PAGE 2 OF 3
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
HYDROGRAPH
UNIT HYDROGRAPH
12AM
6AM
6/19
6/20
6/21
6/22
6/23
6/24
6/25

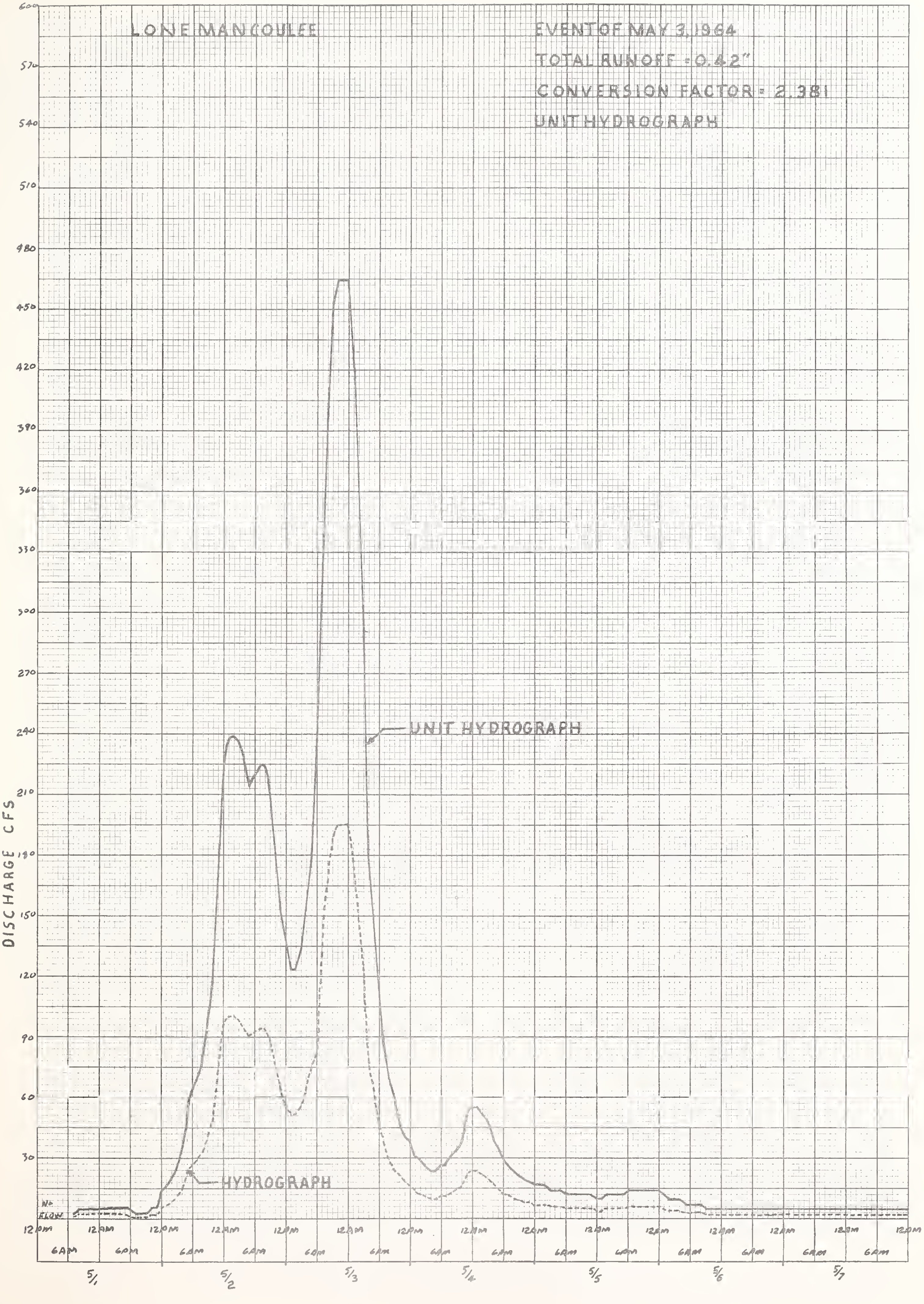

HUMP CREEK
EVENT OF JUNE 14, 1967
PAGE 3 OF 3
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
HYDROGRAPH
UNIT HYDROGRAPH
12 AM
6 AM
12 PM
6 PM
6/26
6/27
6/28
6/29
6/30
7/1
7/2

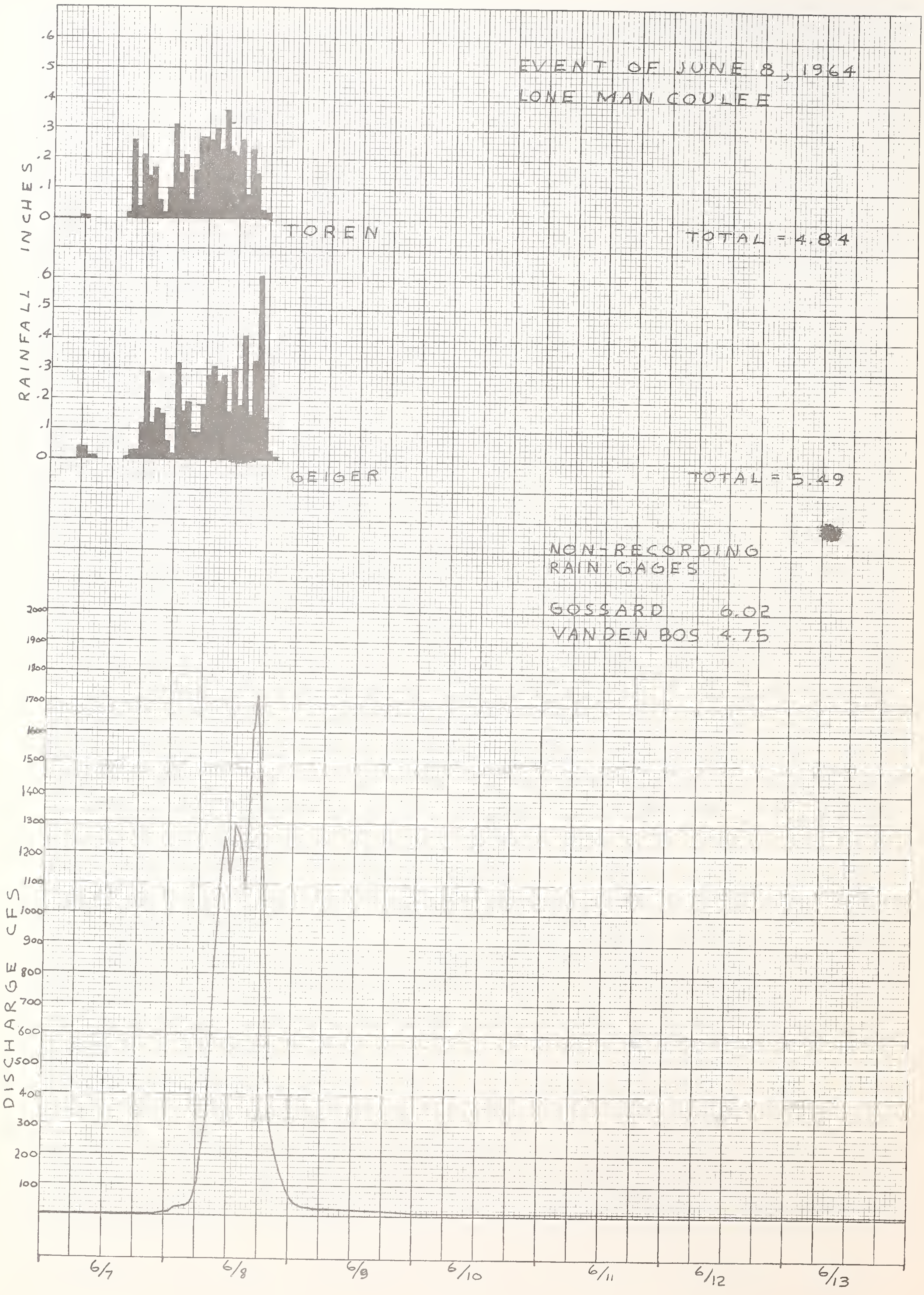

HUMP CREEK
EVENT OF 6/9 ~1968
NON RECORDING GAGES
MYSSE ~TOTAL 3.19
TOTAL RUNOFF - .197"
110
100
90
80
70
60
50
40
30
20
10
0
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
6/7
6/8
6/9
6/10
6/11
6/12
6/13

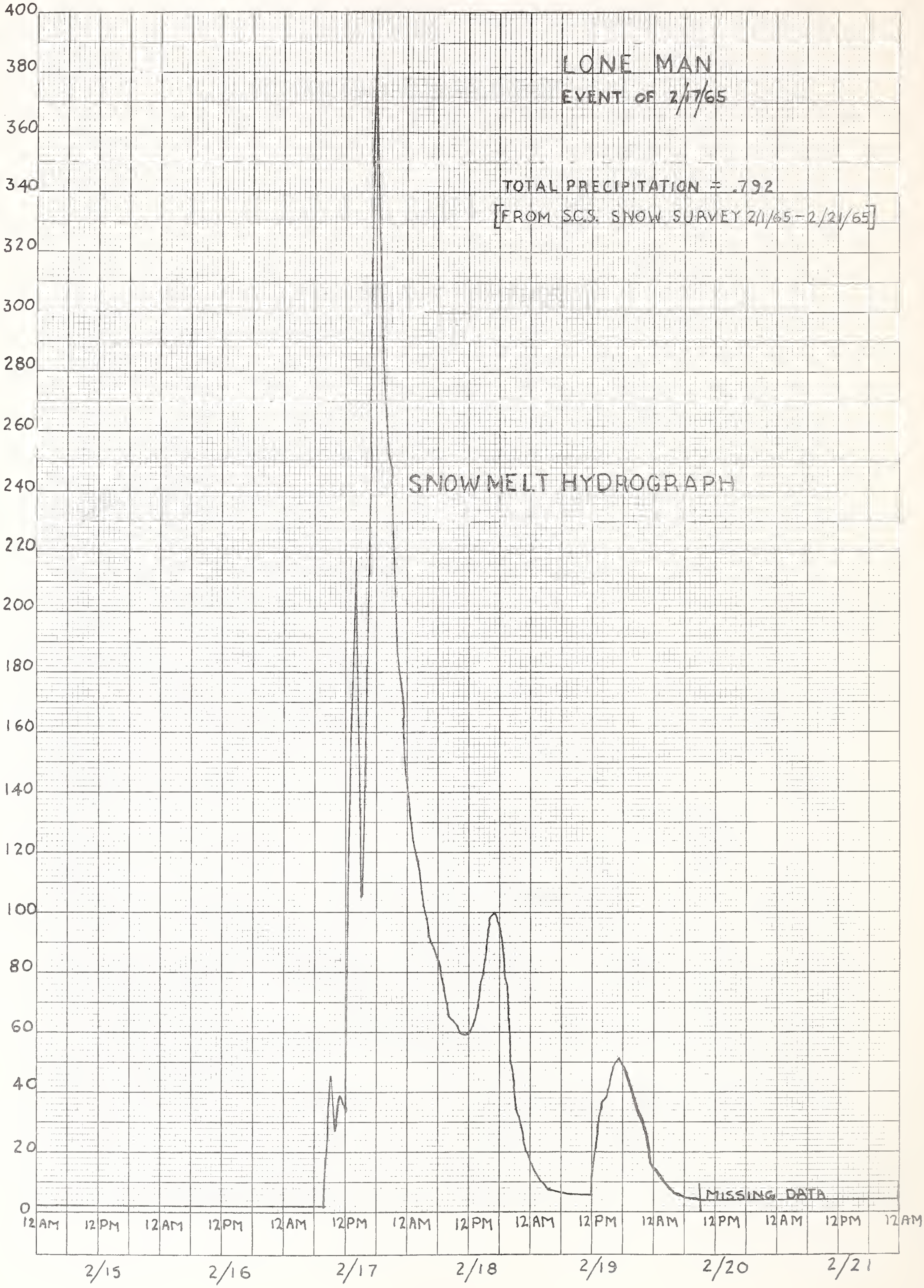

HUMP CREEK
EVENT OF 3/17/69
RAINFALL~CAIN- 0.02"
RAINFALL ~ INCHES
.03
.02
.01
0
NON RECORDING GAGE
MYSSE - 0.00
TOTAL RUNOFF - .099
DISCHARGE - CFS
80
70
60
50
40
30
20
10
0
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
14
15
16
17
18
19
20


EVENT OF MARCH 30, 1964
LONE MAN
RAINFALL-INCHES
.5
.4
.3
.2
.1
0
ZERO PRECIPITATION
GEIGER
RAINFALL-INCHES
.5
.4
.3
.2
.1
0
ZERO PRECIPITATION
TOREN
NON-RECORDING RAIN GAGES:
GOSSARD = 0.00"
VANDEN BOS = 0.00"
DISCHARGE- C.F.S.
100
90
80
70
60
50
40
30
20
10
0
TEMP.
50
40
30
20
10
NO DATA
GEIGER
TEMP.
50
40
30
20
10
NO DATA
TOREN
SNOW MELT HYDROGRAPH
TOTAL RUNOFF = 0.02 INCHES
12 PM
6 AM
12 AM
6 PM
3/27
3/28
3/29
3/30
3/31
4/1
4/2
1964


STORM OF MAY 3, 1964
LONE MAN
RAINFALL - IN.
0
.1
.2
.3
.4
.5
GEIGER
TOTAL PRECIPITATION = 4.49"
10.4 HOURS
11.2 HRS.
TOREN
TOTAL PRECIPITATION = 4.44"
8.3 HOURS
NON-RECORDING RAIN GAGES:
GOSSARD = 5.70"
VANDEN BOS = 5.42"
DISCHARGE - C.F.S.
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
0.17"
0.23"
0.02"
TOTAL RUNOFF = 0.42 INCHES
12pm
6AM
12AB
6 PM
12Pm
6AM
12AM
6PM
12pm
6PM
12AM
6PM
12PM
6AM
12AM
6pm
12PM
6Am
12pm
6pm
12pm
6Am
12Am
6pm
12pm
6Am
6pm
6pm
12pm
5/1
5/2
5/3
5/4
5/5
5/6
5/7
1964


LONE MAN COULEE
EVENT OF MAY 3, 1964
TOTAL RUNOFF = 0.42"
CONVERSION FACTOR = 2.381
UNIT HYDROGRAPH
UNIT HYDROGRAPH
HYDROGRAPH
DISCHARGE CFS
600
570
540
510
480
450
420
390
360
330
300
270
240
210
180
150
120
90
60
30
NO FLOW
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
5/1
5/2
5/3
5/4
5/5
5/6
5/7

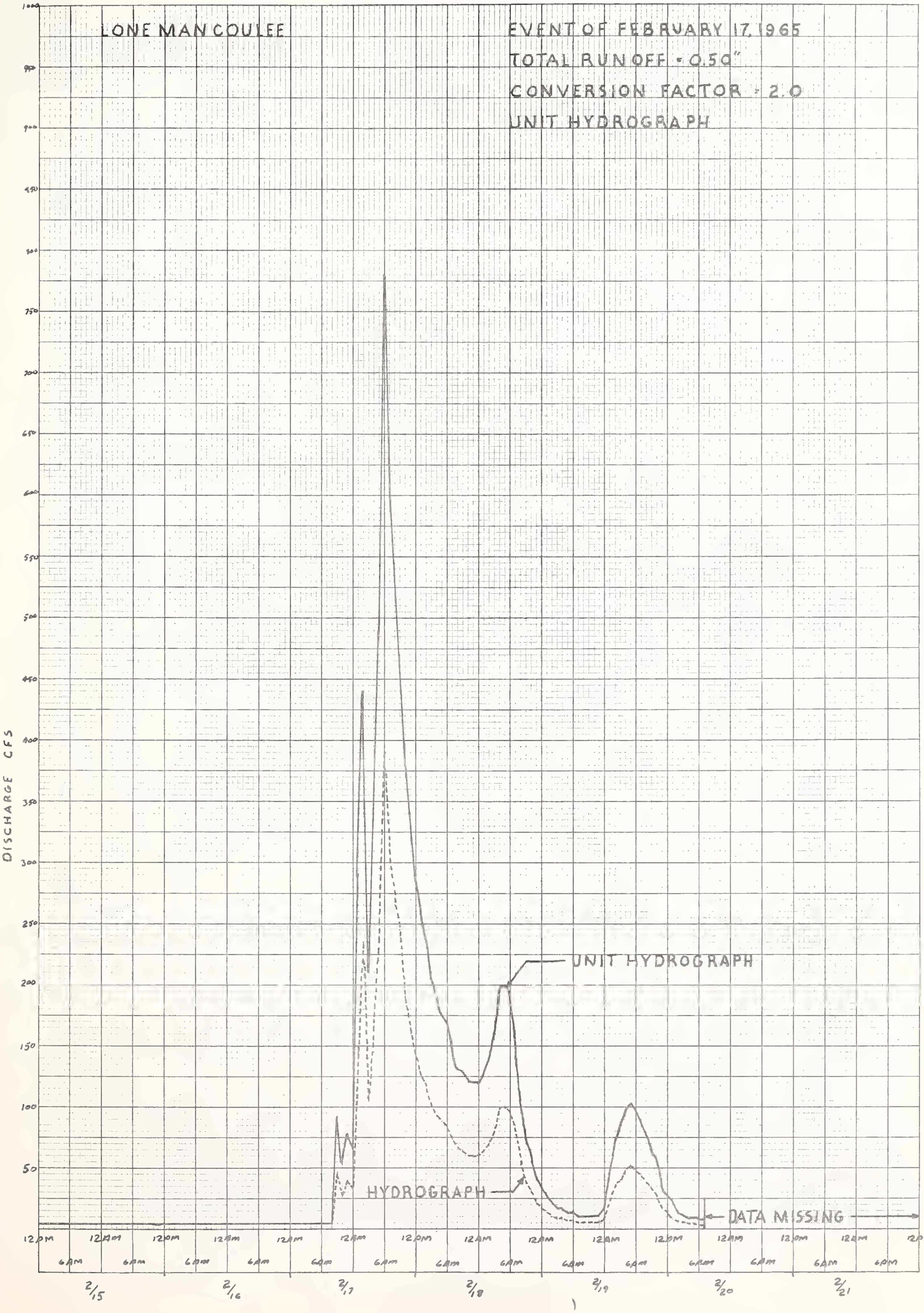

EVENT OF JUNE 8, 1964
LONE MAN COULEE
RAINFALL INCHES
.6
.5
.4
.3
.2
.1
0
TOREN
TOTAL = 4.84
.6
.5
.4
.3
.2
.1
0
GEIGER
TOTAL = 5.49
NON-RECORDING
RAIN GAGES
GOSSARD 6.02
VANDEN BOS 4.75
DISCHARGE CFS
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
6/7
6/8
6/9
6/10
6/11
6/12
6/13

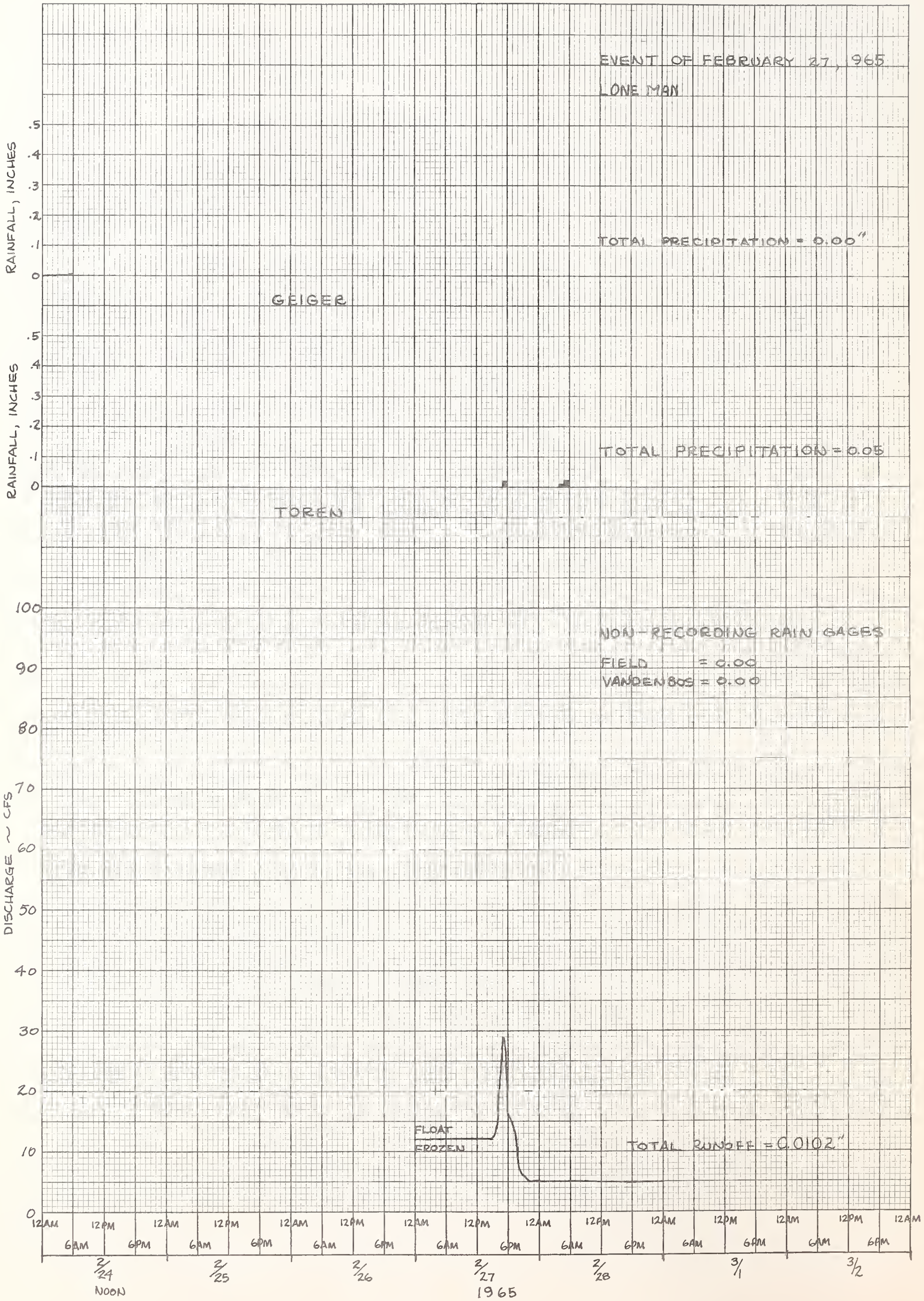


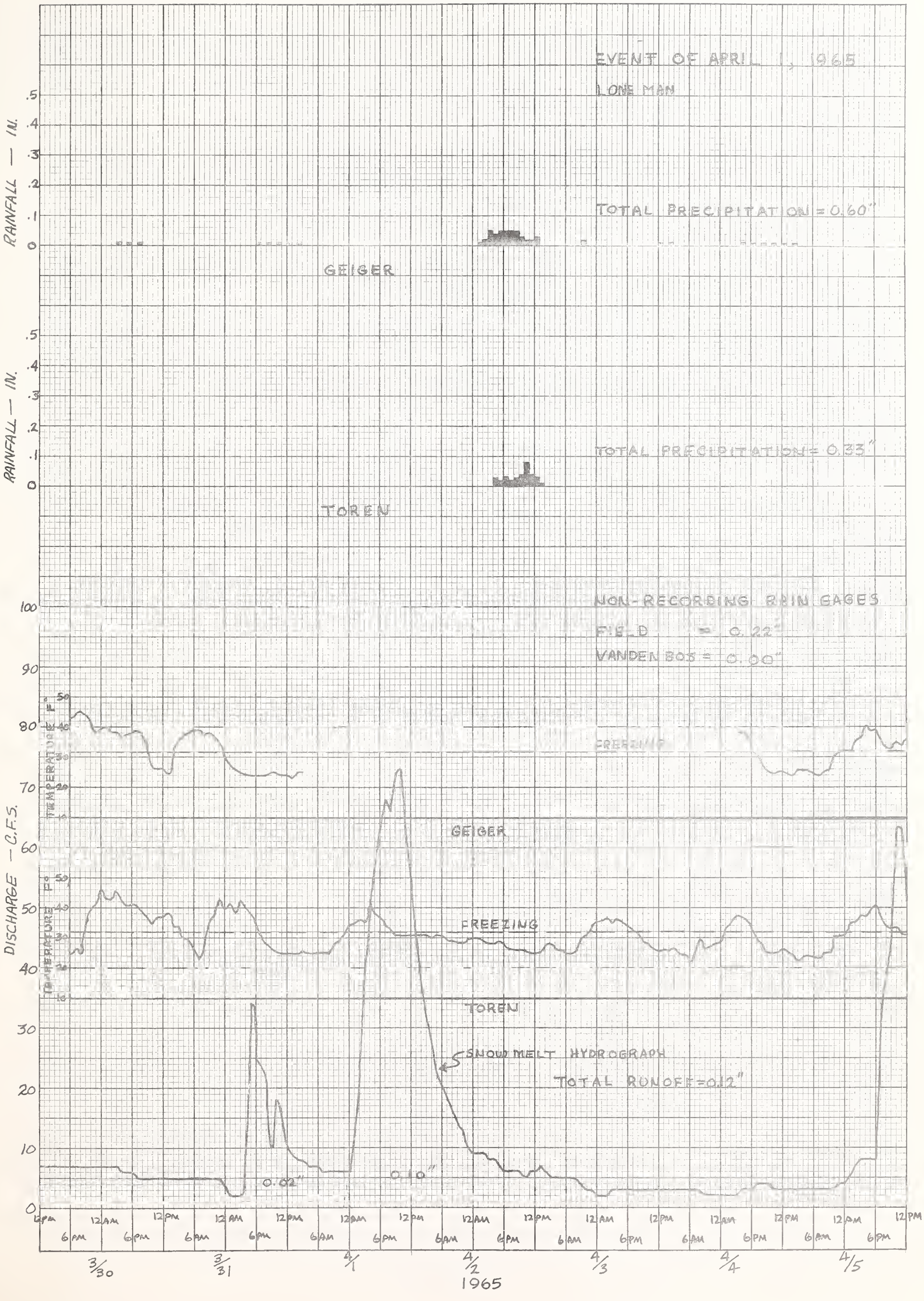
LONE MAN
EVENT OF 2/17/65

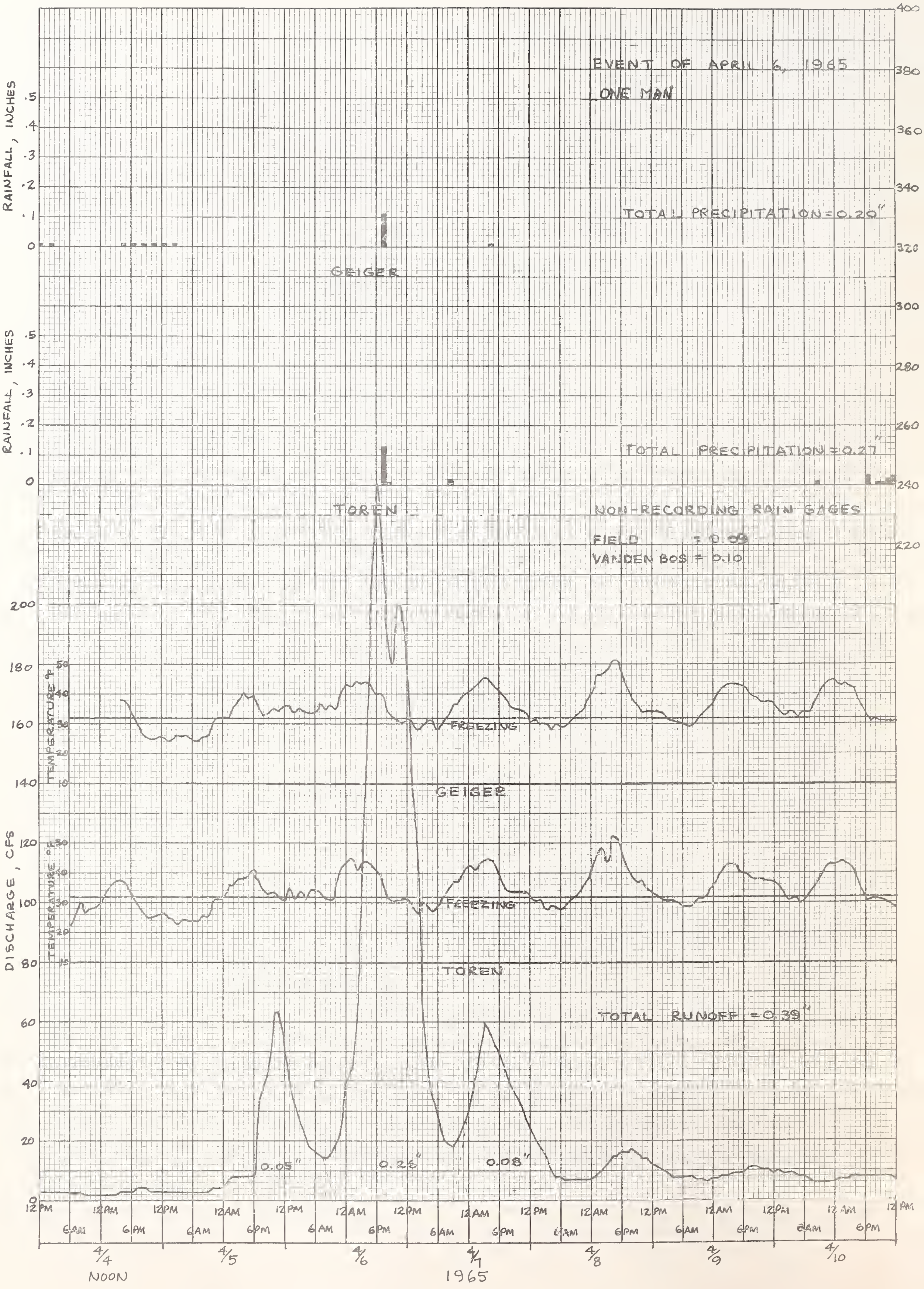
TOTAL PRECIPITATION = .792
[FROM S.C.S. SNOW SURVEY 2/1/65-2/21/65]

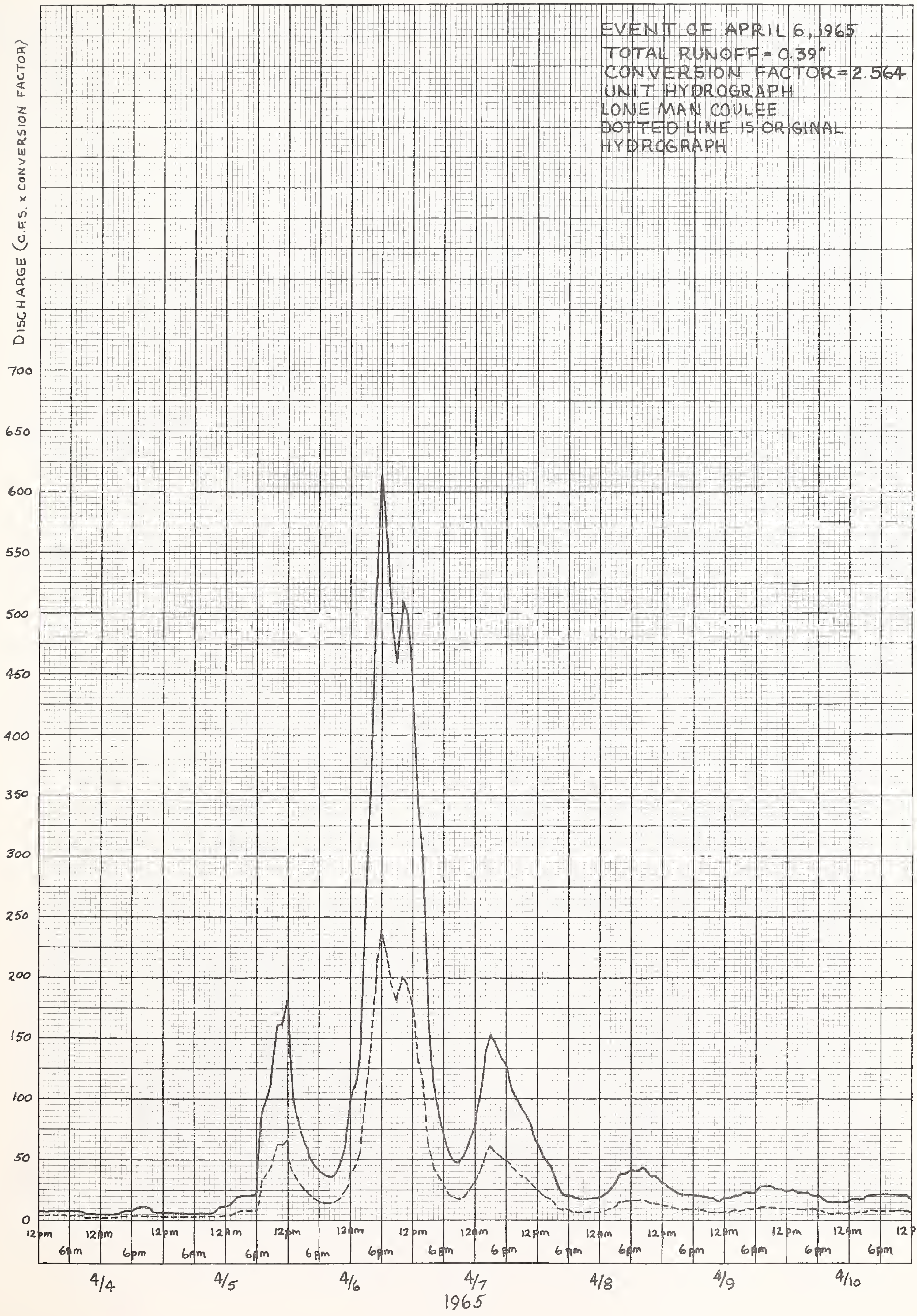
SNOWMELT HYDROGRAPH

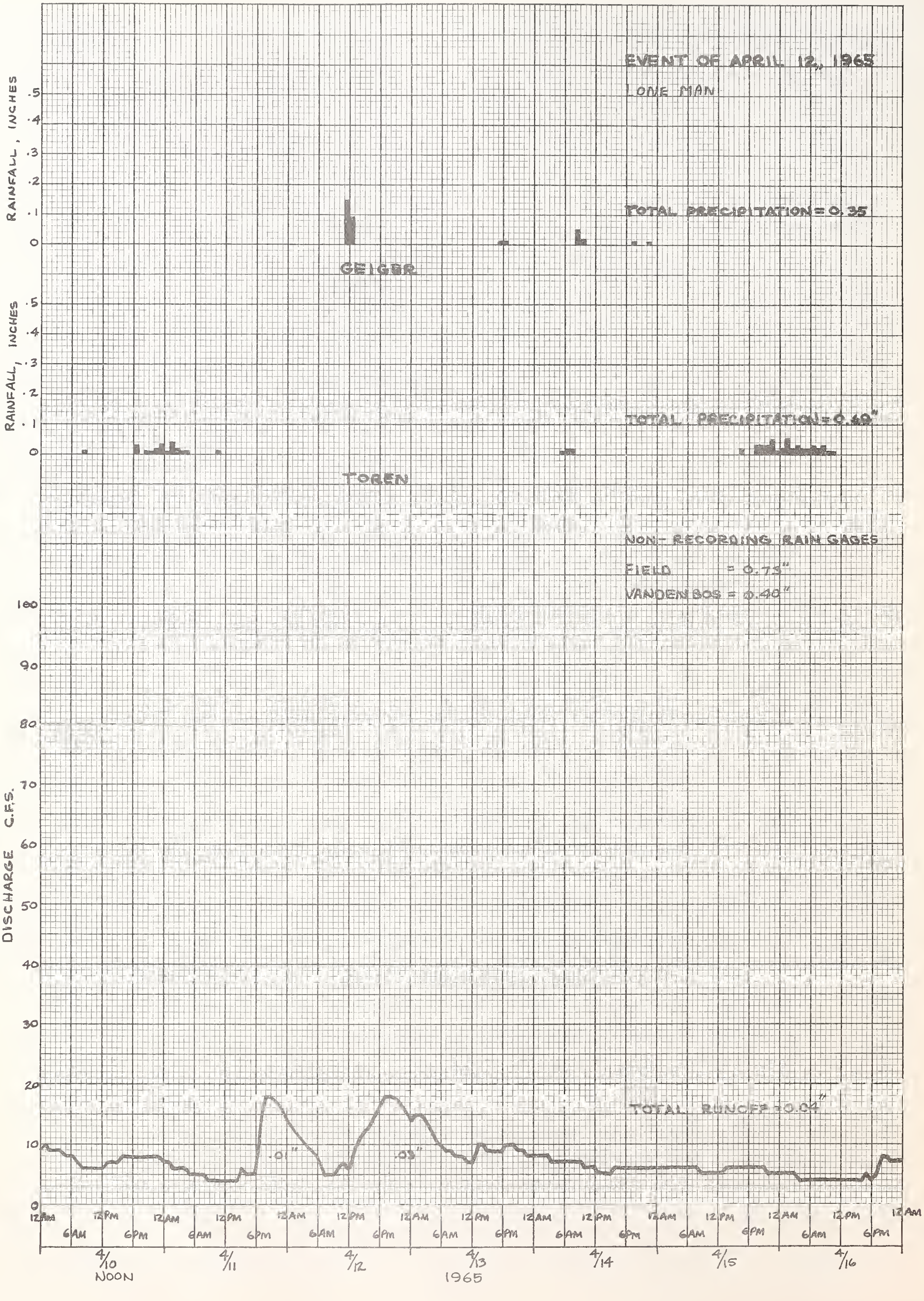

LONE MAN COULEE
EVENT OF FEBRUARY 17, 1965
TOTAL RUNOFF = 0.50"
CONVERSION FACTOR = 2.0
UNIT HYDROGRAPH
DISCHARGE CFS
1000
950
900
850
800
750
700
650
600
550
500
450
400
350
300
250
200
150
100
50
UNIT HYDROGRAPH
HYDROGRAPH
DATA MISSING
12PM
12AM
12PM
12AM
12AM
12AM
12PM
12AM
12AM
12AM
12PM
12AM
12PM
12AM
12PM
6AM
6PM
6PM
6AM
6PM
6AM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
2/15
2/16
2/17
2/18
2/19
2/20
2/21


EVENT OF FEBRUARY 27, 1965
LONE MAN
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.00"
GEIGER
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.05
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.00
VANDENBOS = 0.00
DISCHARGE ~ CFS
100
90
80
70
60
50
40
30
20
10
0
FLOAT
FROZEN
TOTAL RUNOFF = 0.0102"
12AM
12PM
6AM
6PM
2/24
NOON
2/25
2/26
2/27
1965
2/28
3/1
3/2


EVENT OF APRIL 1, 1965
LONE MAN
RAINFALL — IN.
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.60"
GEIGER
RAINFALL — IN.
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.33"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.22"
VANDEN BOS = 0.00"
100
90
80
70
60
50
40
30
20
10
0
DISCHARGE — C.F.S.
TEMPERATURE F°
50
40
30
20
10
FREEZING
GEIGER
TEMPERATURE F°
50
40
30
20
10
FREEZING
TOREN
SNOW MELT HYDROGRAPH
TOTAL RUNOFF = 0.12"
0.02"
0.10"
12 PM
6 PM
12 AM
6 AM
3/30
3/31
4/1
4/2
4/3
4/4
4/5
1965


EVENT OF APRIL 6, 1965
LONE MAN
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.20"
GEIGER
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.27"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.09
VANDEN BOS = 0.10
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
TEMPERATURE °F
50
40
30
20
10
FREEZING
GEIGER
TEMPERATURE °F
50
40
30
20
15
FREEZING
TOREN
DISCHARGE, CFS
TOTAL RUNOFF = 0.39"
0.05"
0.25"
0.08"
12 PM
6 AM
12 PM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
4/4
NOON
4/5
4/6
4/7
4/8
4/9
4/10
1965


EVENT OF APRIL 6, 1965
TOTAL RUNOFF = 0.39"
CONVERSION FACTOR = 2.564
UNIT HYDROGRAPH
LONE MAN COULEE
DOTTED LINE IS ORIGINAL HYDROGRAPH
DISCHARGE (C.F.S. x CONVERSION FACTOR)
700
650
600
550
500
450
400
350
300
250
200
150
100
50
0
12pm
12Am
12pm
12Am
12pm
12Am
12pm
12Am
12pm
12Am
12pm
12Am
12pm
12Am
12pm
6Am
6pm
6Am
6pm
6pm
6Am
6pm
6Am
6pm
6Am
6pm
6Am
6pm
6Am
6pm
4/4
4/5
4/6
4/7
4/8
4/9
4/10
1965


EVENT OF APRIL 12, 1965

LONE MAN

TOTAL PRECIPITATION = 0.35

GEIGER

TOTAL PRECIPITATION = 0.49"

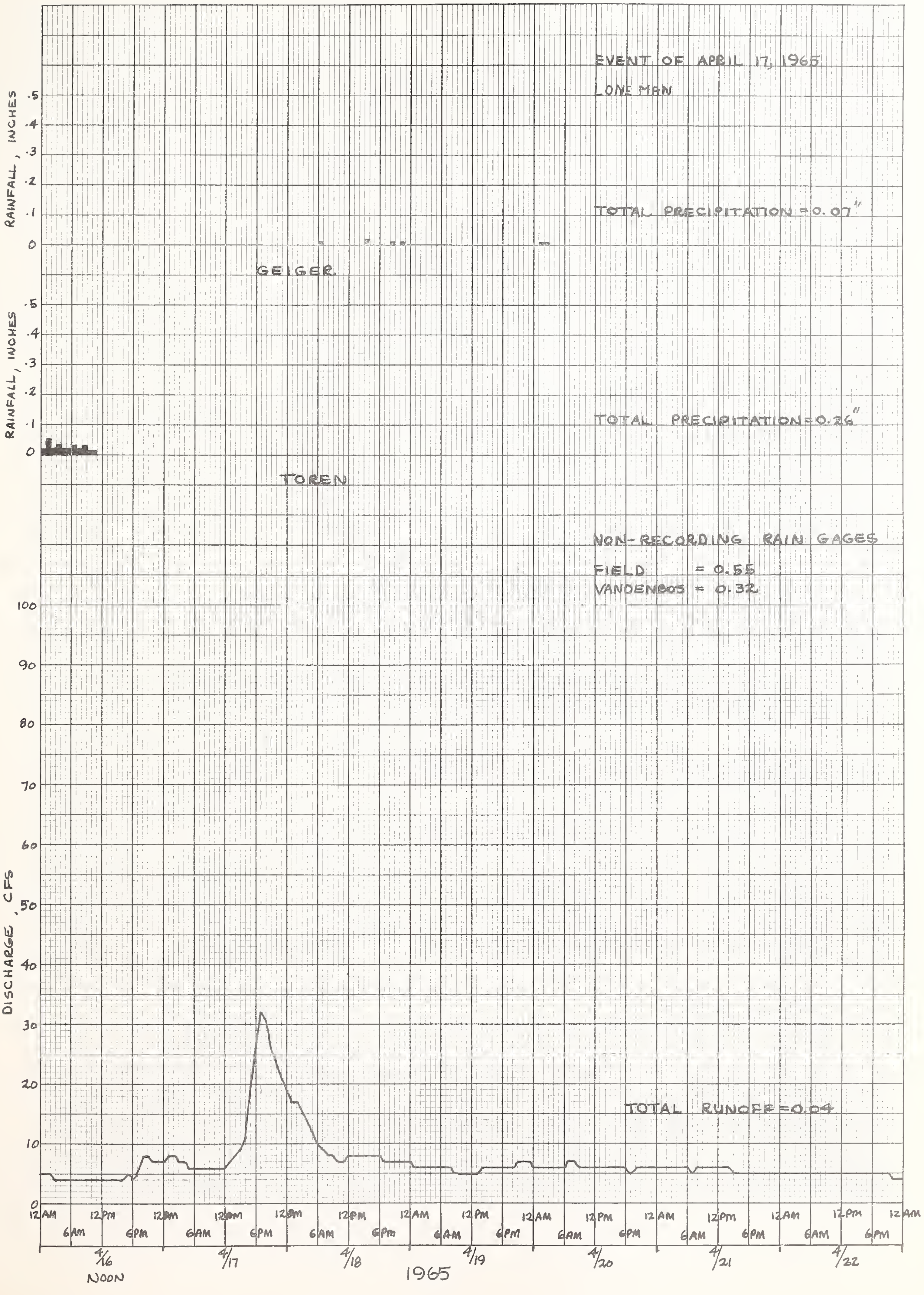
TOREN

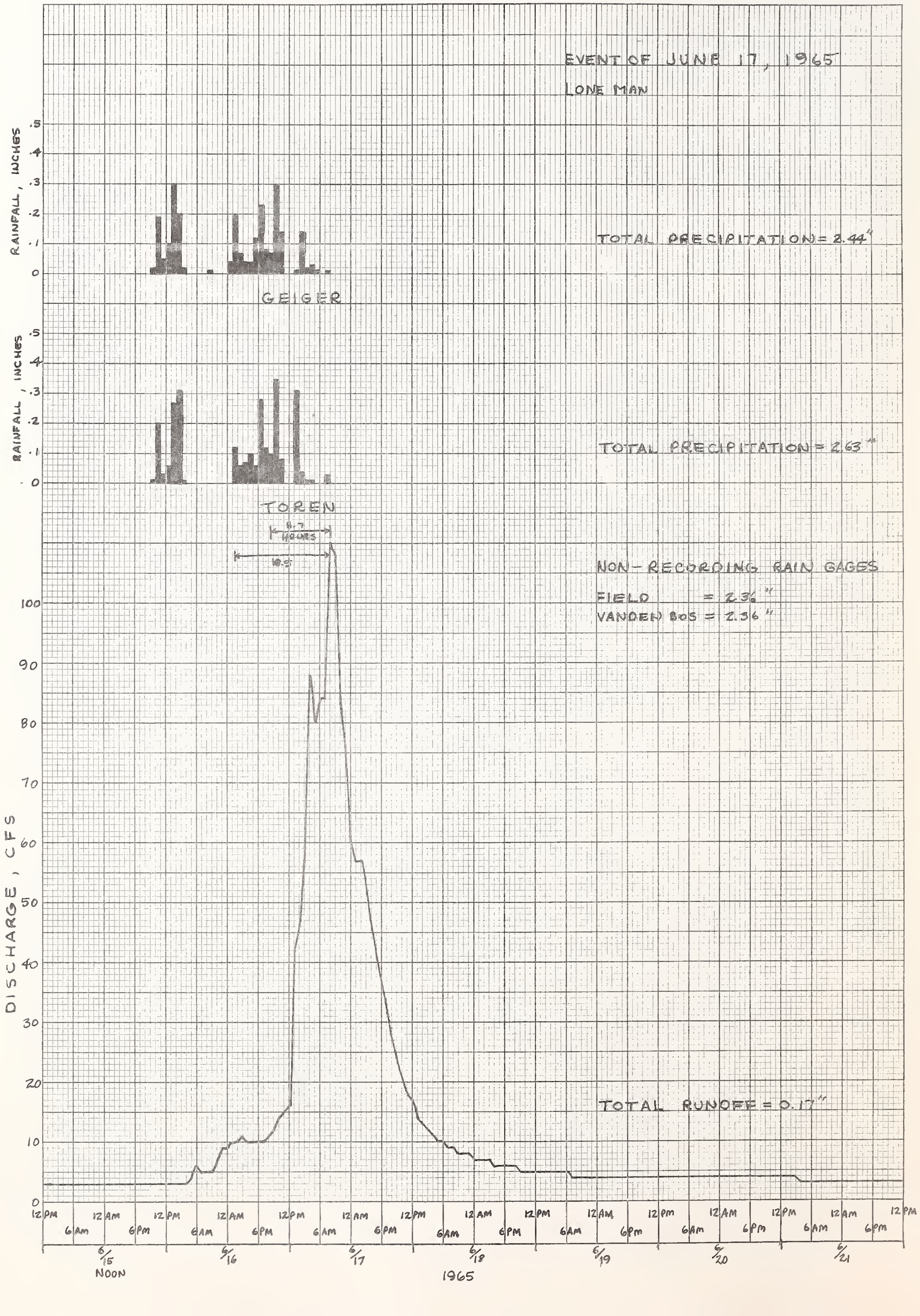
NON-RECORDING RAIN GAGES

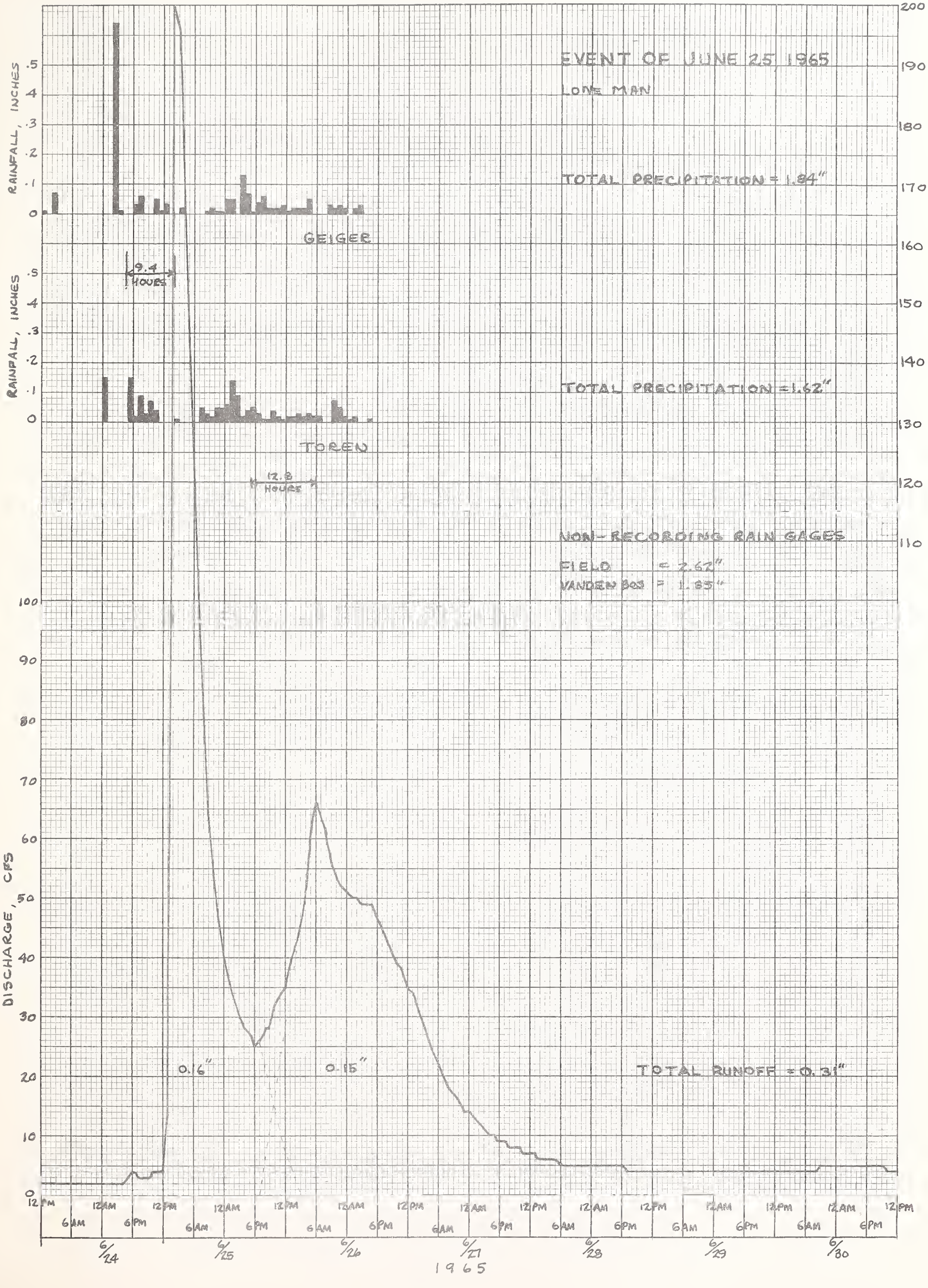
FIELD = 0.73"

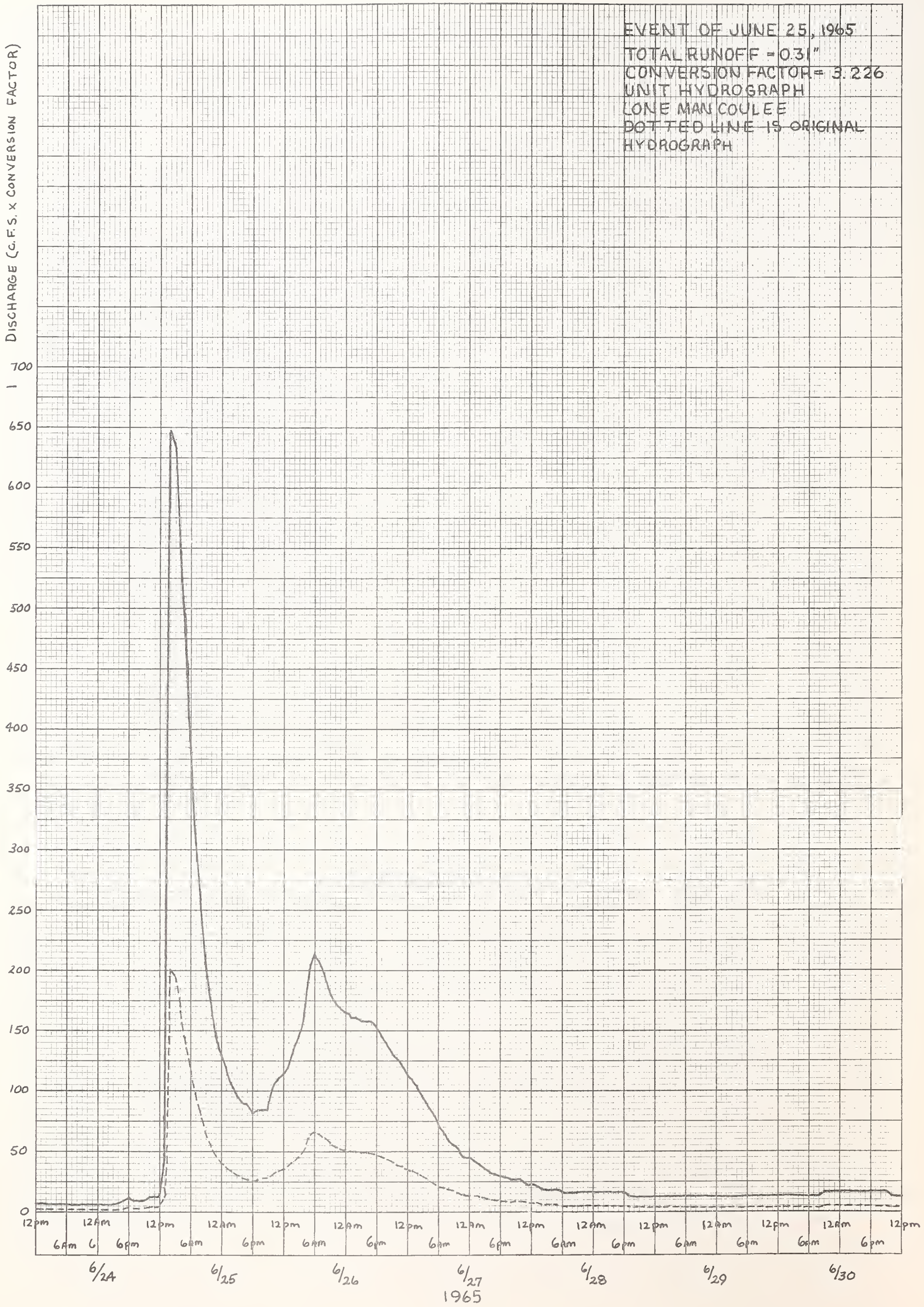
VANDEN BOS = 0.40"

TOTAL RUNOFF = 0.04"

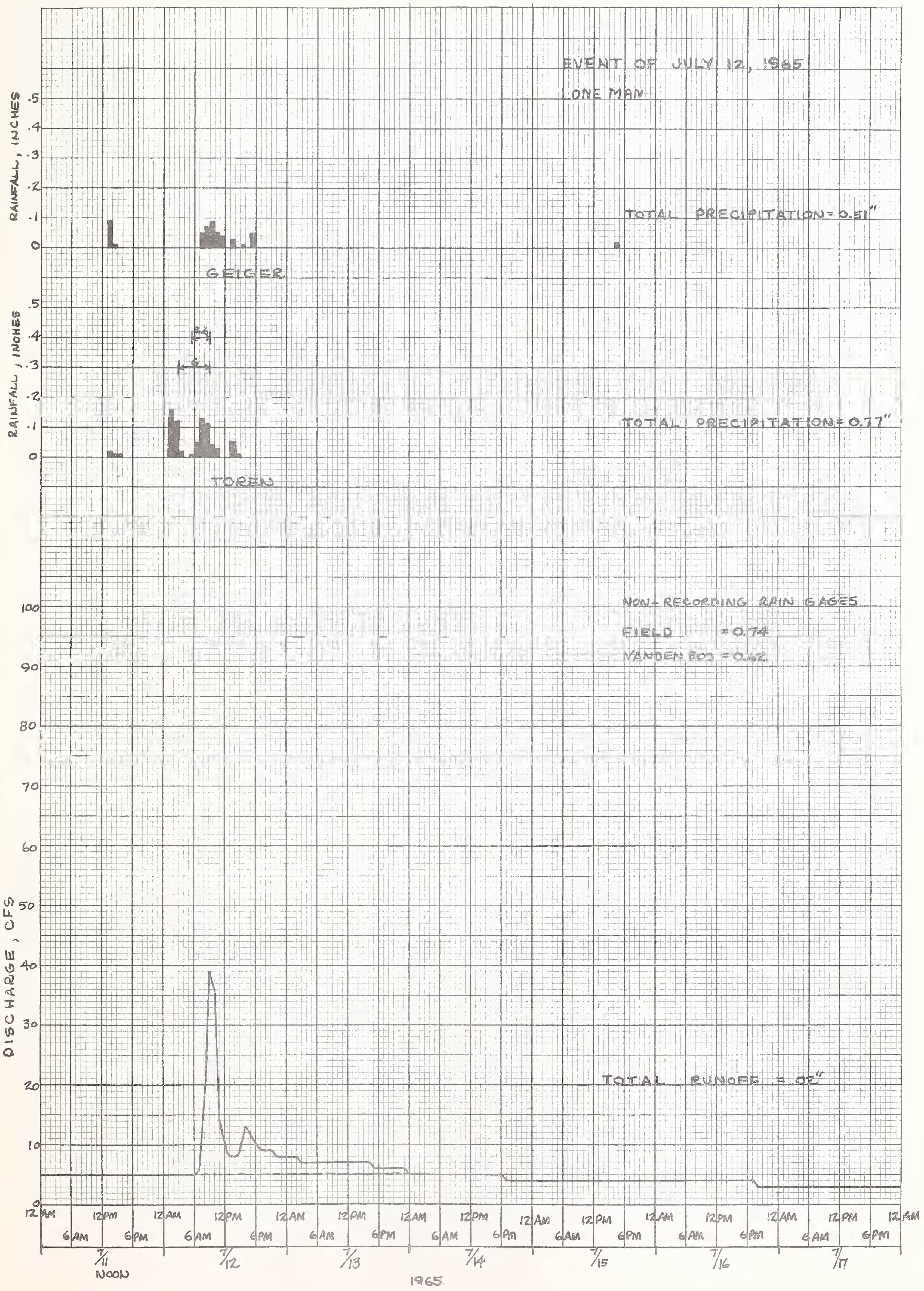

EVENT OF APRIL 17, 1965
LONE MAN
TOTAL PRECIPITATION = 0.07"
GEIGER
TOTAL PRECIPITATION = 0.26"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.55
VANDENBOS = 0.32
TOTAL RUNOFF = 0.04
RAINFALL, INCHES
0
.1
.2
.3
.4
.5
RAINFALL, INCHES
0
.1
.2
.3
.4
.5
DISCHARGE, CFS
0
10
20
30
40
50
60
70
80
90
100
12 AM
6AM
12 PM
6PM
12 AM
6AM
12 AM
6PM
12 AM
6AM
12 PM
6PM
12 AM
6AM
12 PM
6PM
12 AM
6AM
12 PM
6PM
12 AM
6AM
12 PM
6PM
12 AM
6AM
12 PM
6PM
12 AM
4/16
NOON
4/17
4/18
4/19
4/20
4/21
4/22
1965

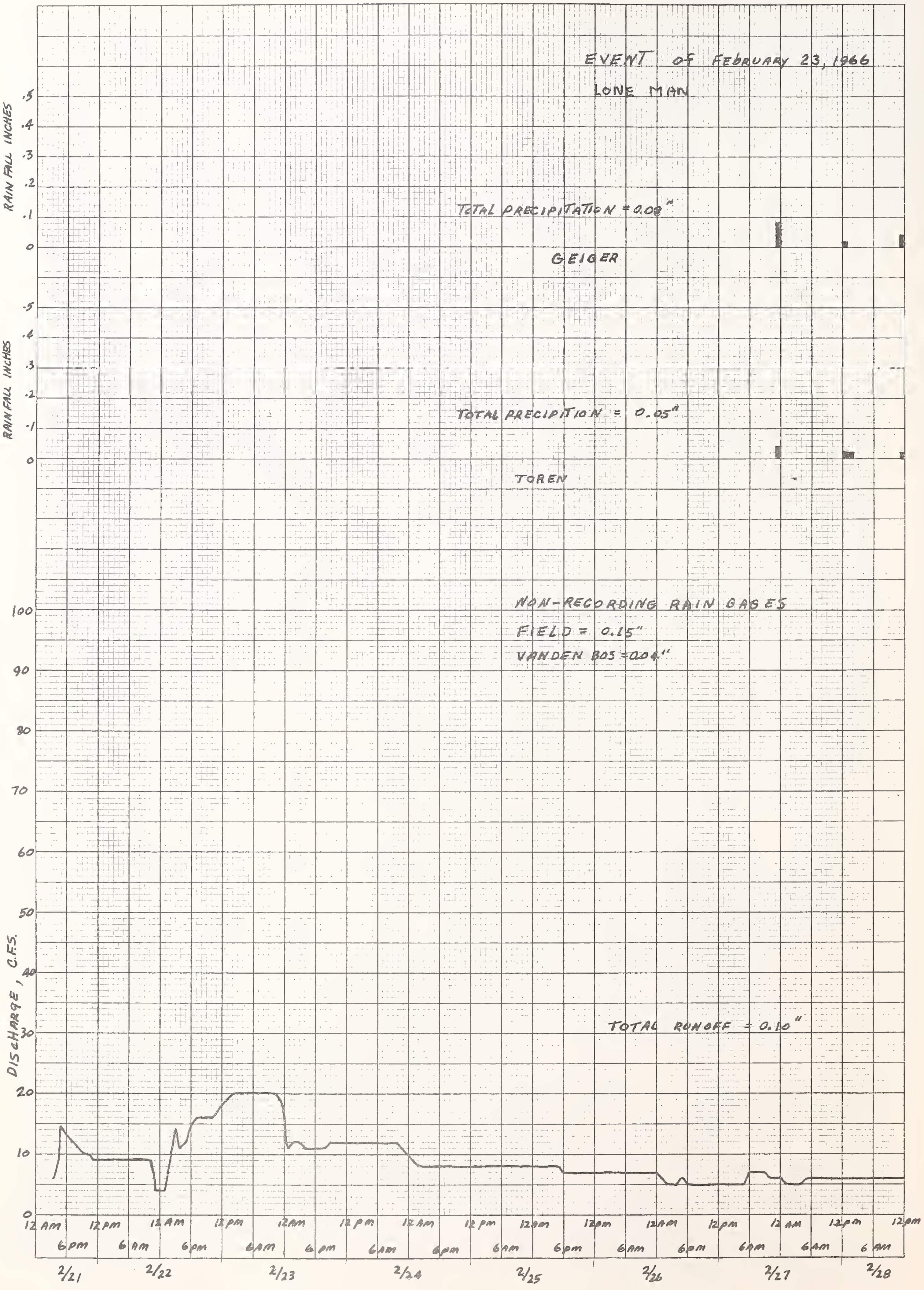

EVENT OF JUNE 17, 1965
LONE MAN
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 2.44"
GEIGER
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 2.63"
TOREN
4.7 HOURS
10.5
NON-RECORDING RAIN GAGES
FIELD = 2.36"
VANDEN BOS = 2.36"
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF = 0.17"
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6 AM
12 AM
6 PM
12 PM
6/15
NOON
6/16
6/17
6/18
6/19
6/20
6/21
1965


EVENT OF JUNE 25, 1965
LONE MAN
TOTAL PRECIPITATION = 1.84"
GEIGER
9.4 HOURS
TOTAL PRECIPITATION = 1.62"
TOREN
12.8 HOURS
NON-RECORDING RAIN GAGES
FIELD = 2.62"
VANDEN BOS = 1.85"
0.16"
0.15"
TOTAL RUNOFF = 0.31"
RAINFALL, INCHES
0
.1
.2
.3
.4
.5
DISCHARGE, CFS
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
12 PM
6 AM
12 AM
6 PM
6/24
6/25
6/26
6/27
6/28
6/29
6/30
1965



EVENT OF JUNE 25, 1965
TOTAL RUNOFF = 0.31"
CONVERSION FACTOR = 3.226
UNIT HYDROGRAPH
LONE MAN COULEE
DOTTED LINE IS ORIGINAL HYDROGRAPH


EVENT OF JULY 12, 1965
ONE MAN
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 0.51"
GEIGER
RAINFALL, INCHES
.5
.4
.3
.2
.1
0
2.6
6
TOTAL PRECIPITATION = 0.77"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.74
VANDEN BOS = 0.62
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF = .02"
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
6 AM
12 PM
6 PM
12 AM
7/11
NOON
7/12
7/13
7/14
7/15
7/16
7/17
1965



EVENT of FEBRUARY 23, 1966
LONE MAN

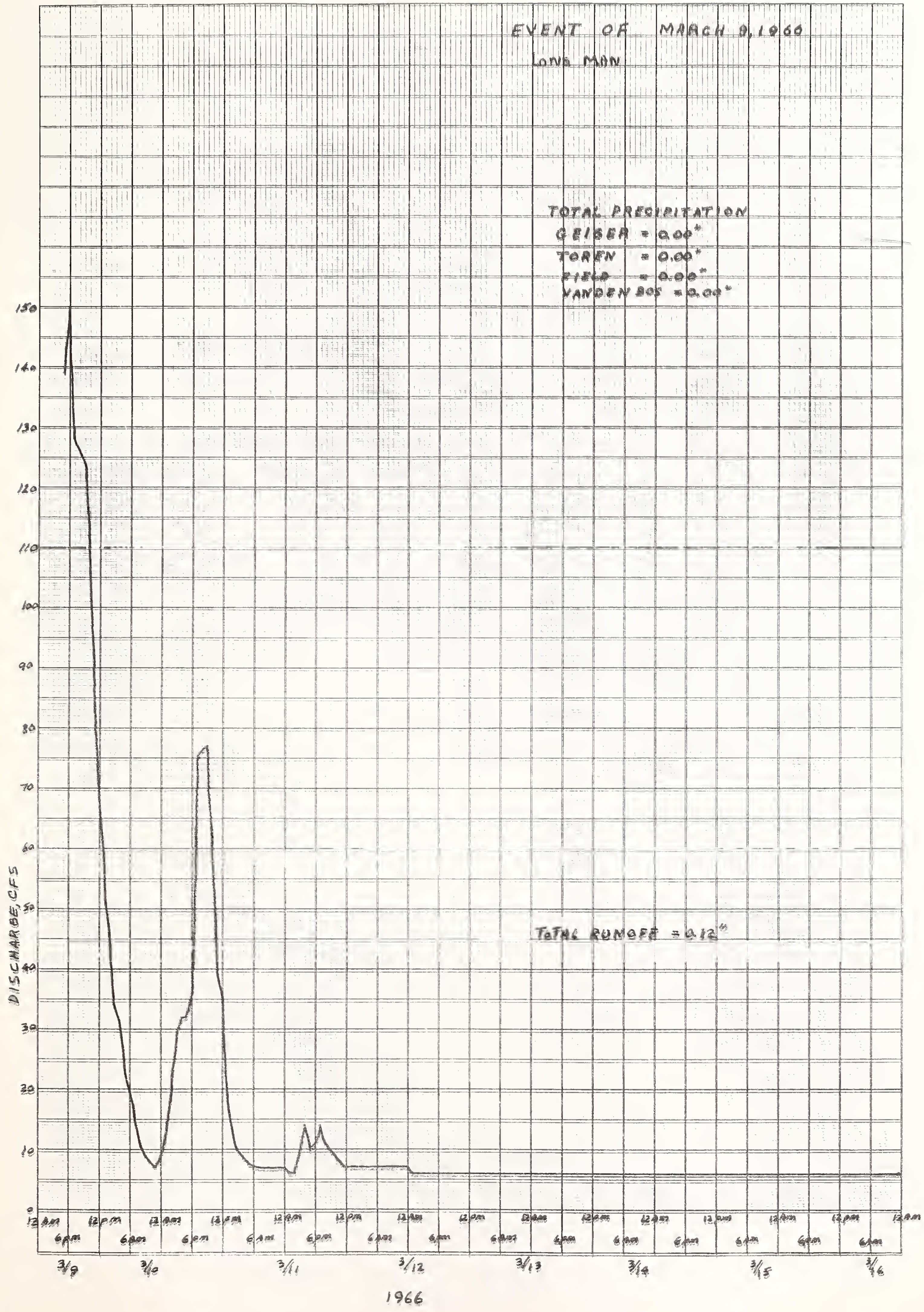
TOTAL PRECIPITATION = 0.08"
GEIGER

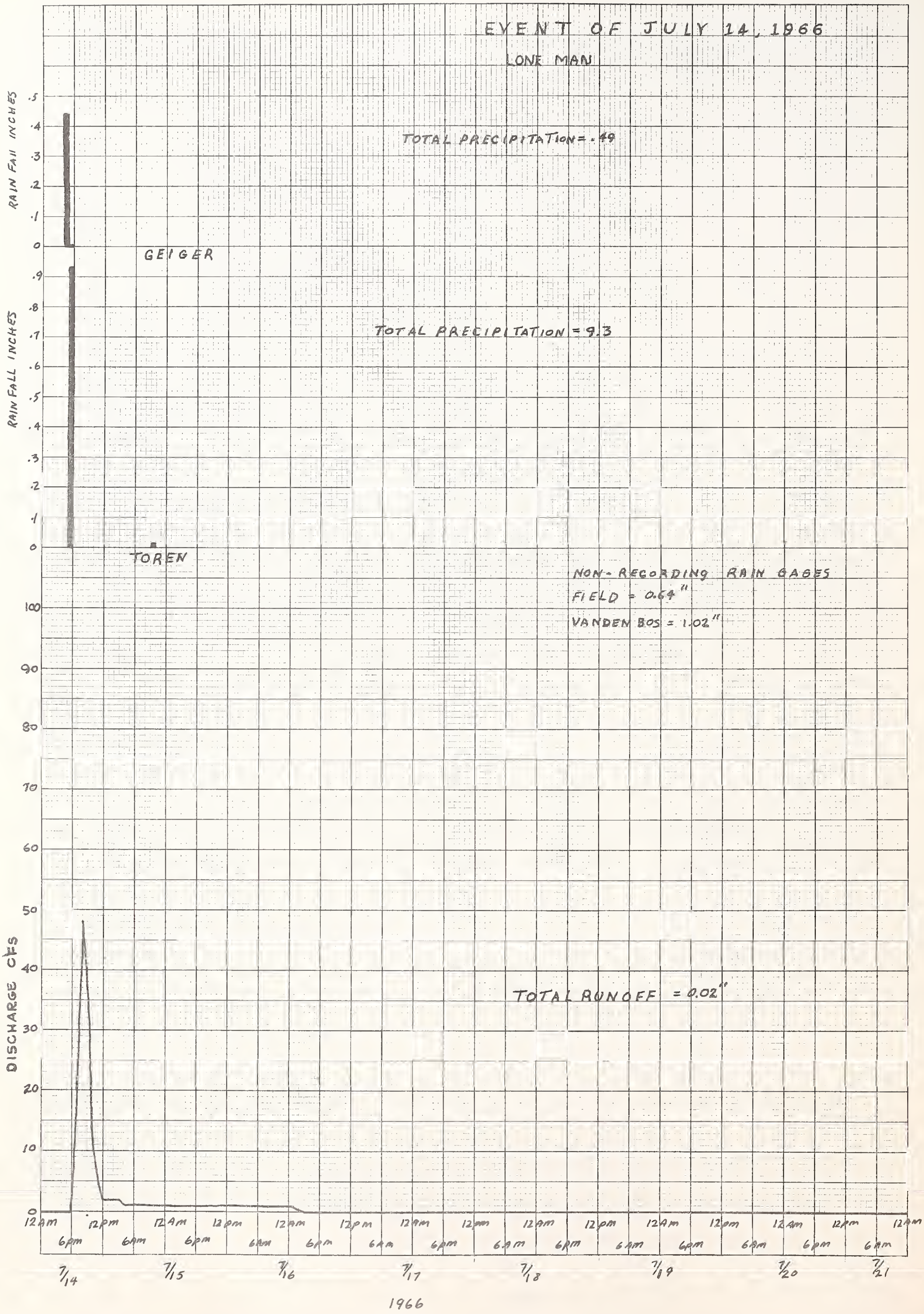
TOTAL PRECIPITION = 0.05"
TOREN

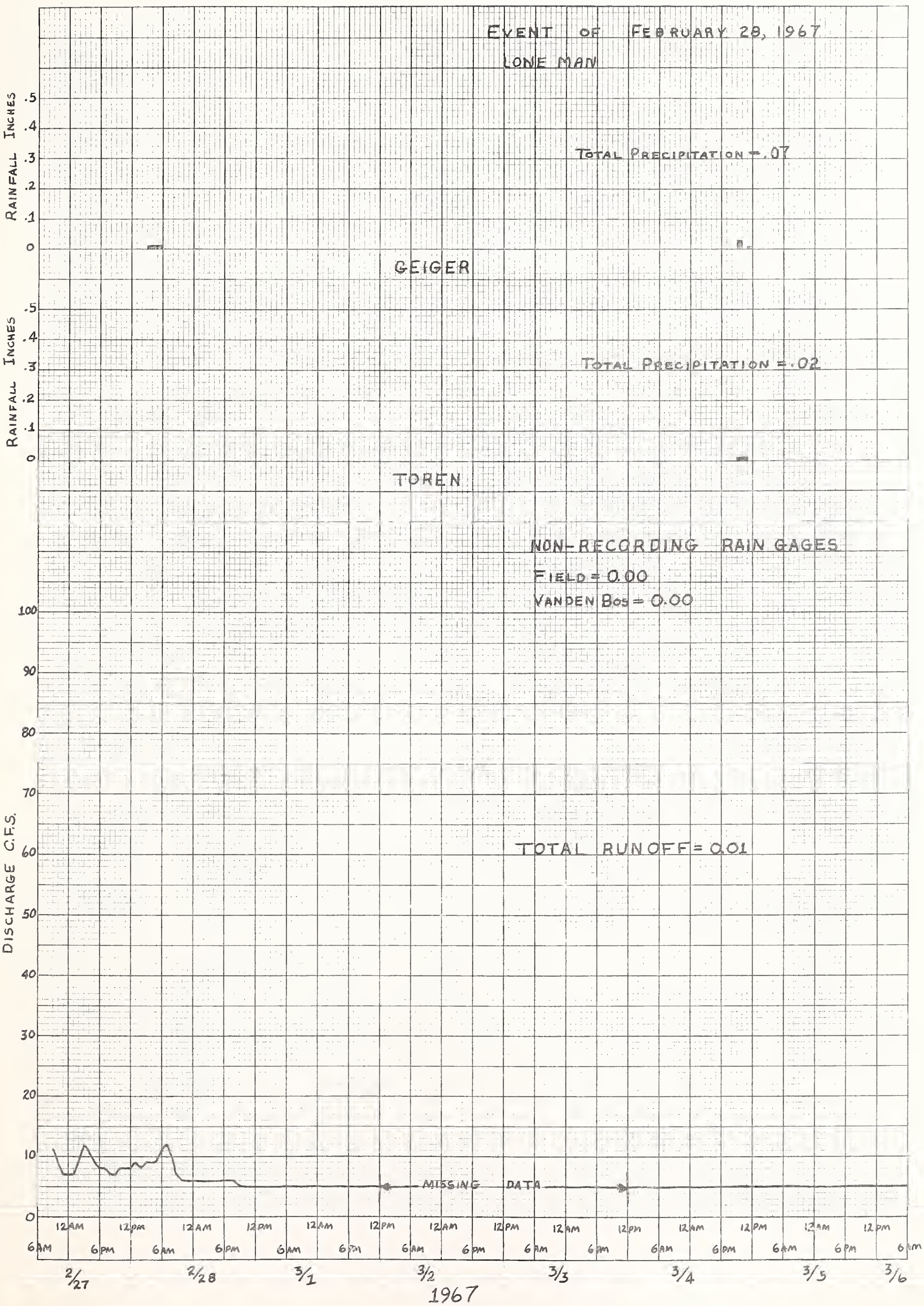
NON-RECORDING RAIN GAGES
FIELD = 0.15"
VANDEN BOS = 0.04"

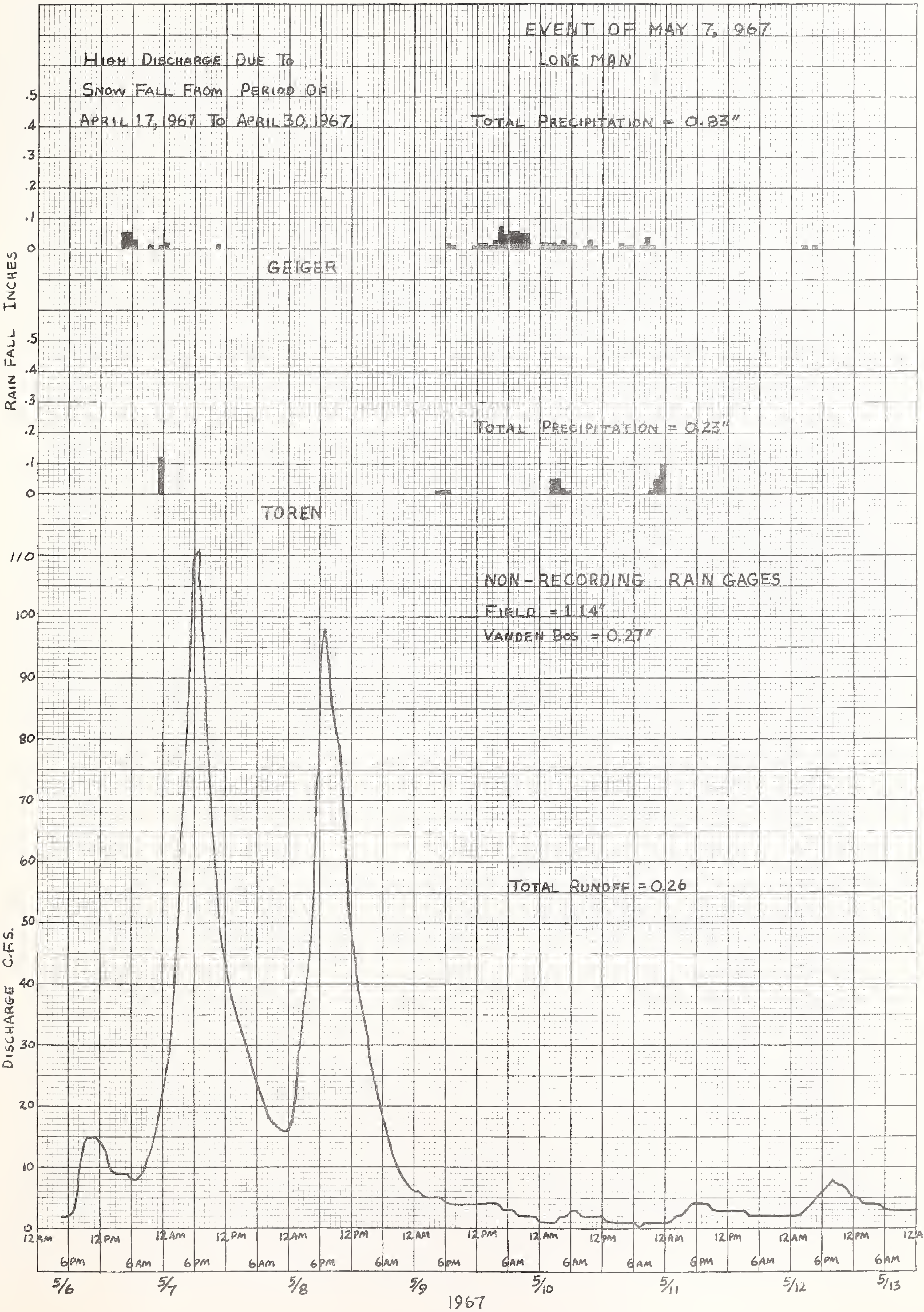
TOTAL RUNOFF = 0.10"

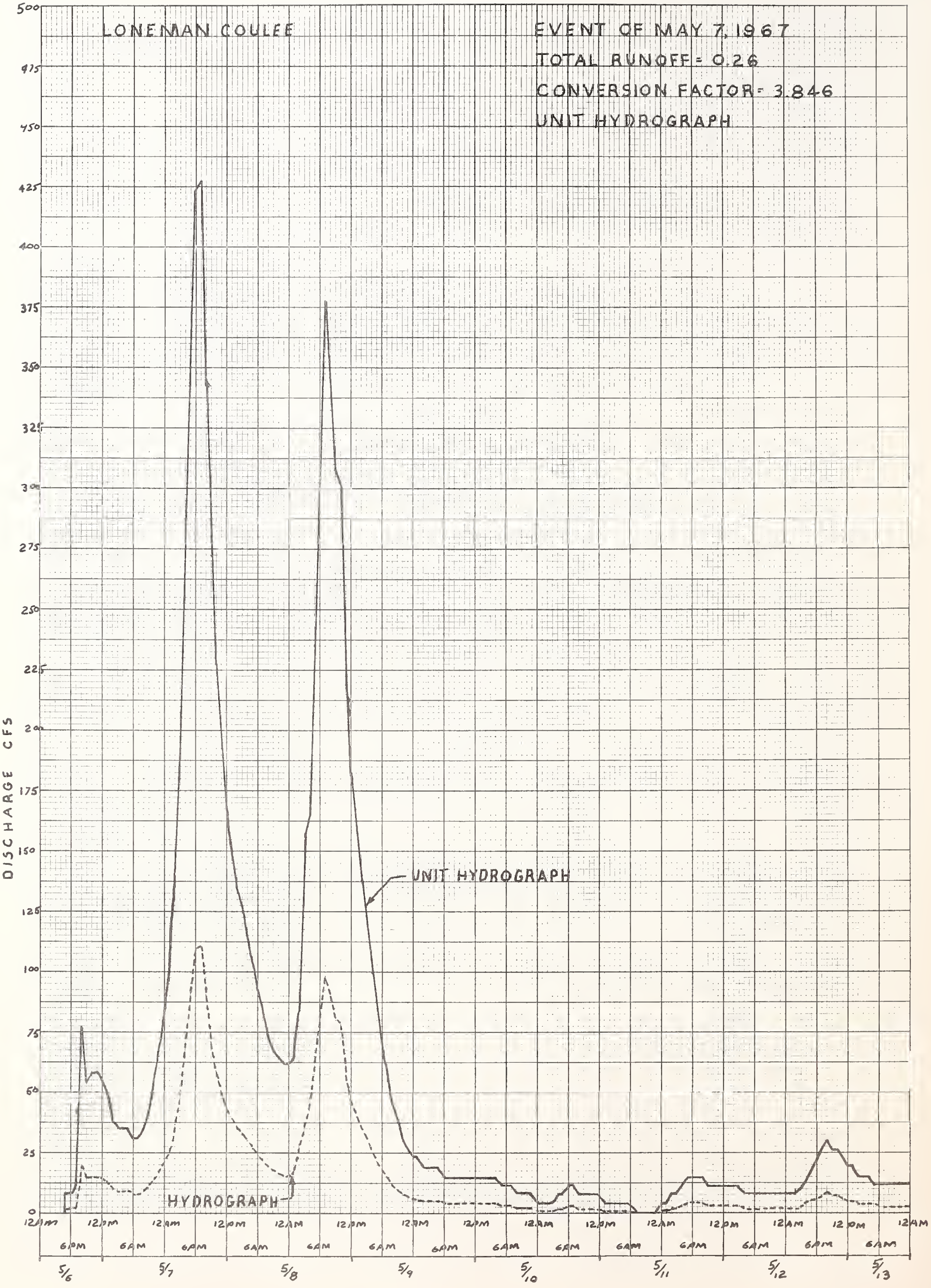
1966

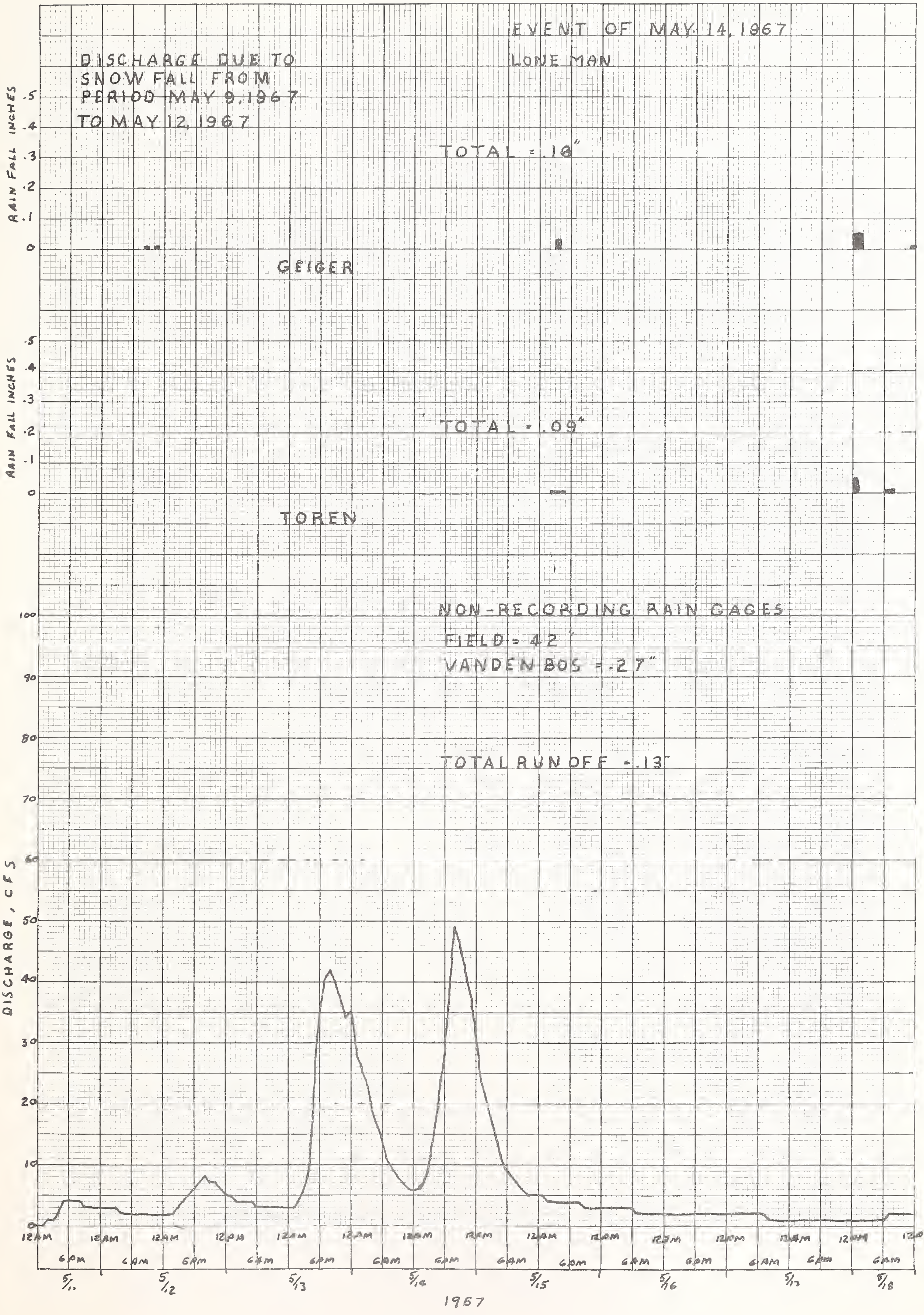

EVENT OF MARCH 9, 1966
LONG MAN
TOTAL PRECIPITATION
GEISER = 0.00"
TOREN = 0.00"
FIELD = 0.00"
VANDEN BOS = 0.00"
TOTAL RUNOFF = 0.12"
DISCHARGE, CFS
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
12 AM
6 AM
12 PM
6 PM
3/9
3/10
3/11
3/12
3/13
3/14
3/15
3/16
1966

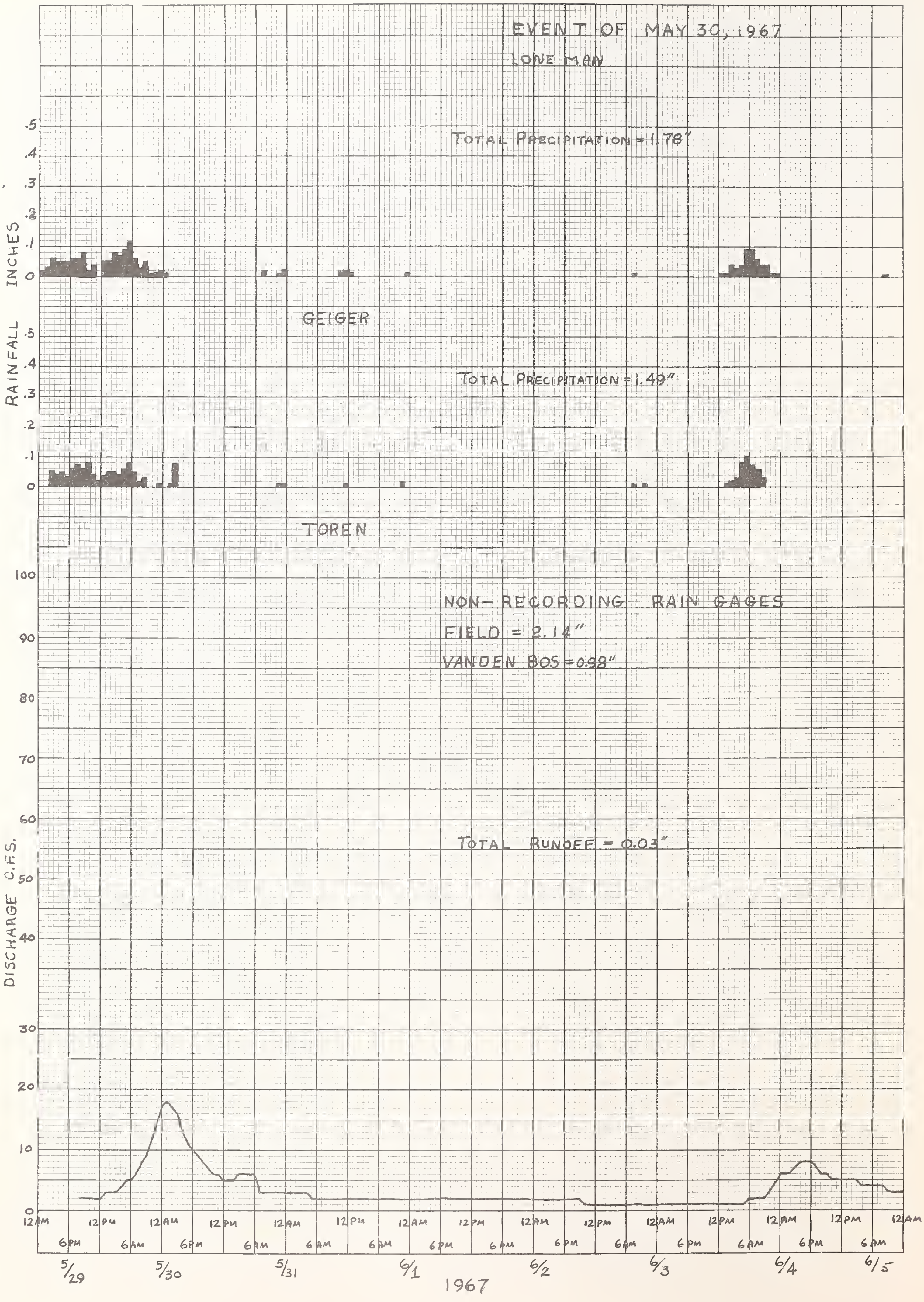

EVENT OF JULY 14, 1966
LONE MAN
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = .49
GEIGER
RAINFALL INCHES
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = 9.3
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.64"
VANDEN BOS = 1.02"
DISCHARGE CFS
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF = 0.02"
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
6pm
12pm
6AM
12AM
7/14
7/15
7/16
7/17
7/18
7/19
7/20
7/21
1966

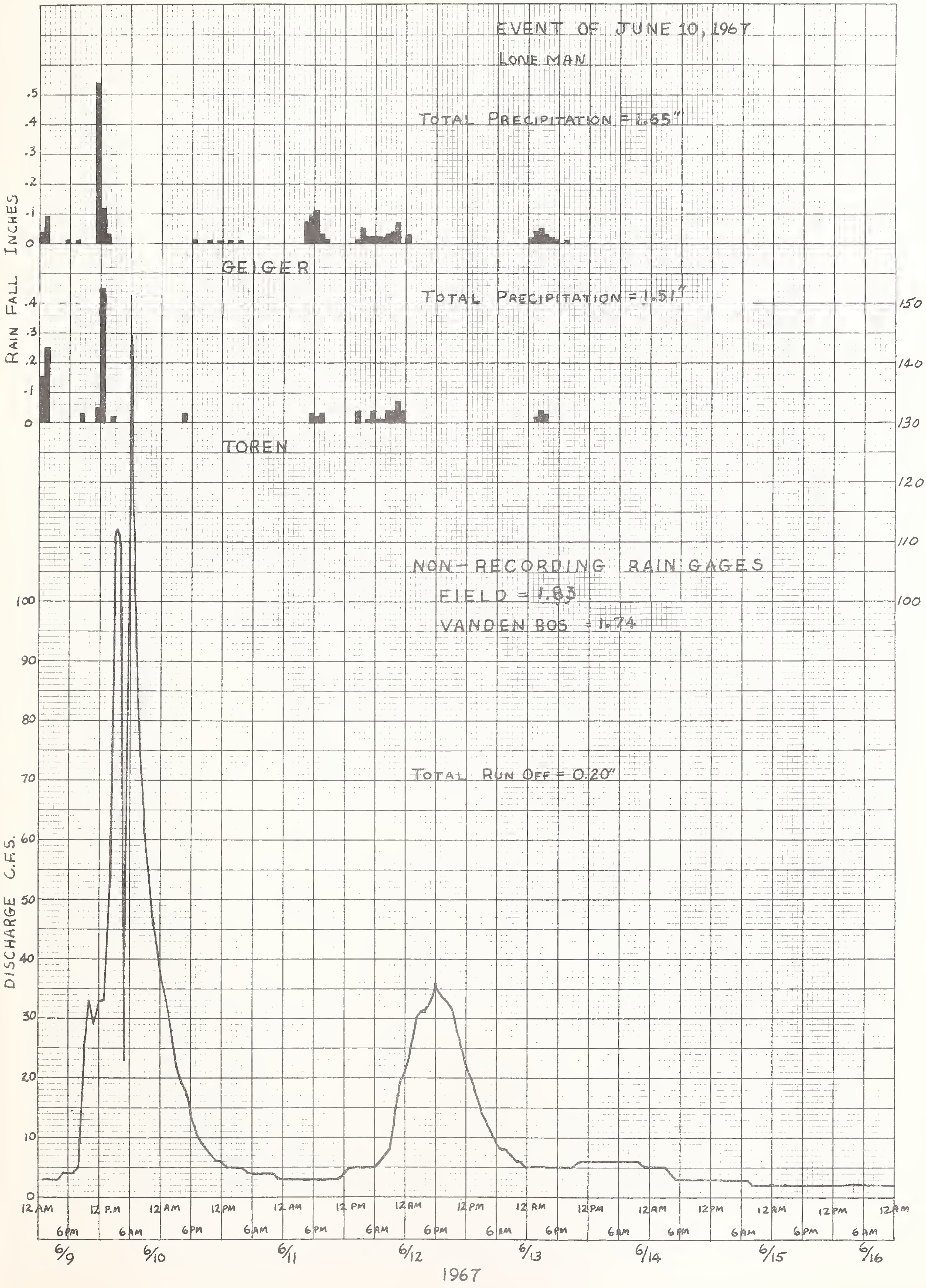

EVENT OF FEBRUARY 28, 1967
LONE MAN
RAINFALL INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = .07
GEIGER
RAINFALL INCHES
.5
.4
.3
.2
.1
0
TOTAL PRECIPITATION = .02
TOREN
NON-RECORDING RAIN GAGES
FIELD = 0.00
VANDEN BOS = 0.00
DISCHARGE C.F.S.
100
90
80
70
60
50
40
30
20
10
0
TOTAL RUNOFF = 0.01
MISSING DATA
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
2/27
2/28
3/1
3/2
3/3
3/4
3/5
3/6
1967

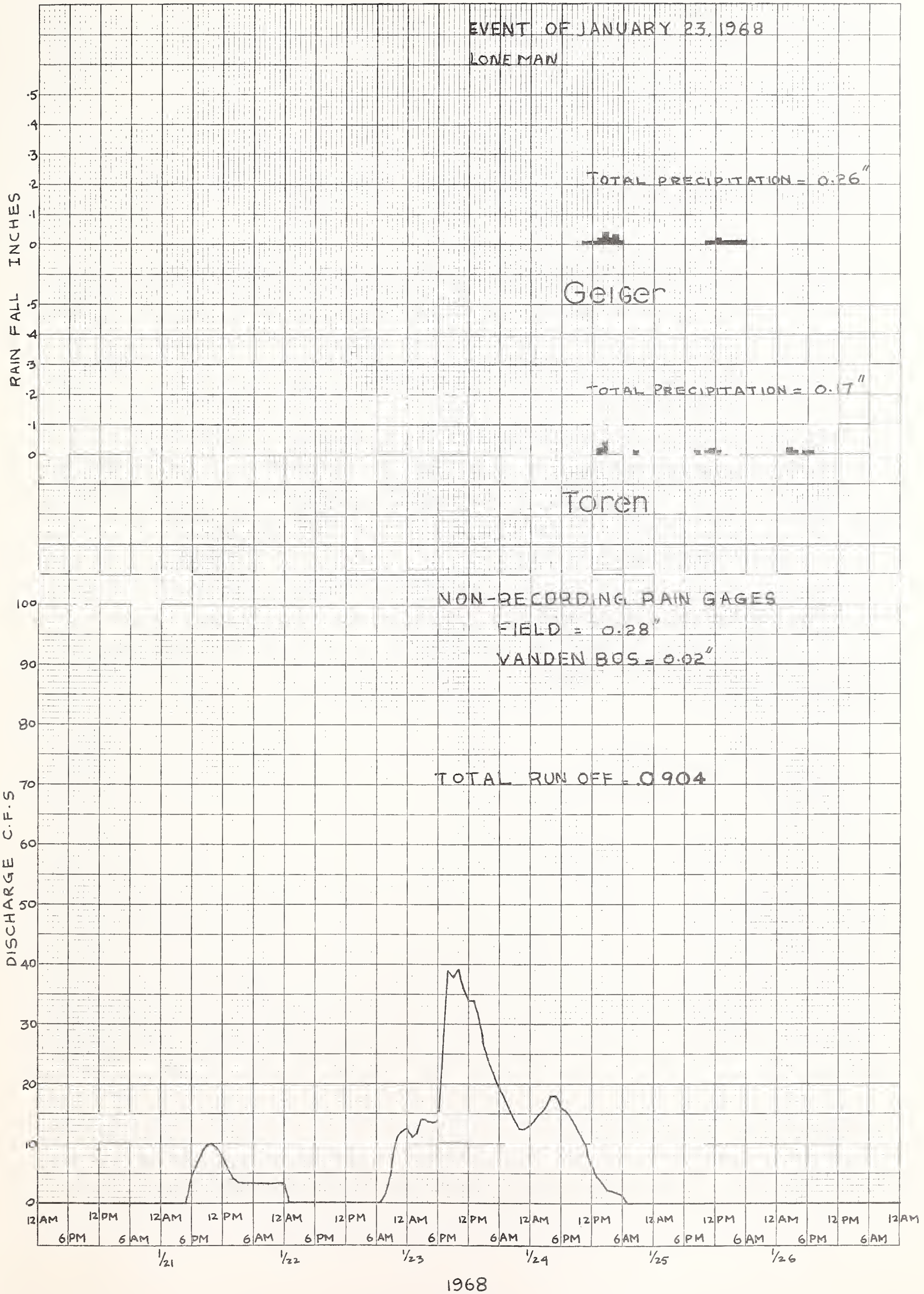

EVENT OF MAY 7, 1967
LONE MAN
HIGH DISCHARGE DUE TO
SNOW FALL FROM PERIOD OF
APRIL 17, 1967 TO APRIL 30, 1967.
TOTAL PRECIPITATION = 0.83"
GEIGER
TOTAL PRECIPITATION = 0.23"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 1.14"
VANDEN BOS = 0.27"
TOTAL RUNOFF = 0.26
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
DISCHARGE C.F.S.
110
100
90
80
70
60
50
40
30
20
10
0
12 AM
12 PM
6 PM
6 AM
5/6
5/7
5/8
5/9
5/10
5/11
5/12
5/13
1967

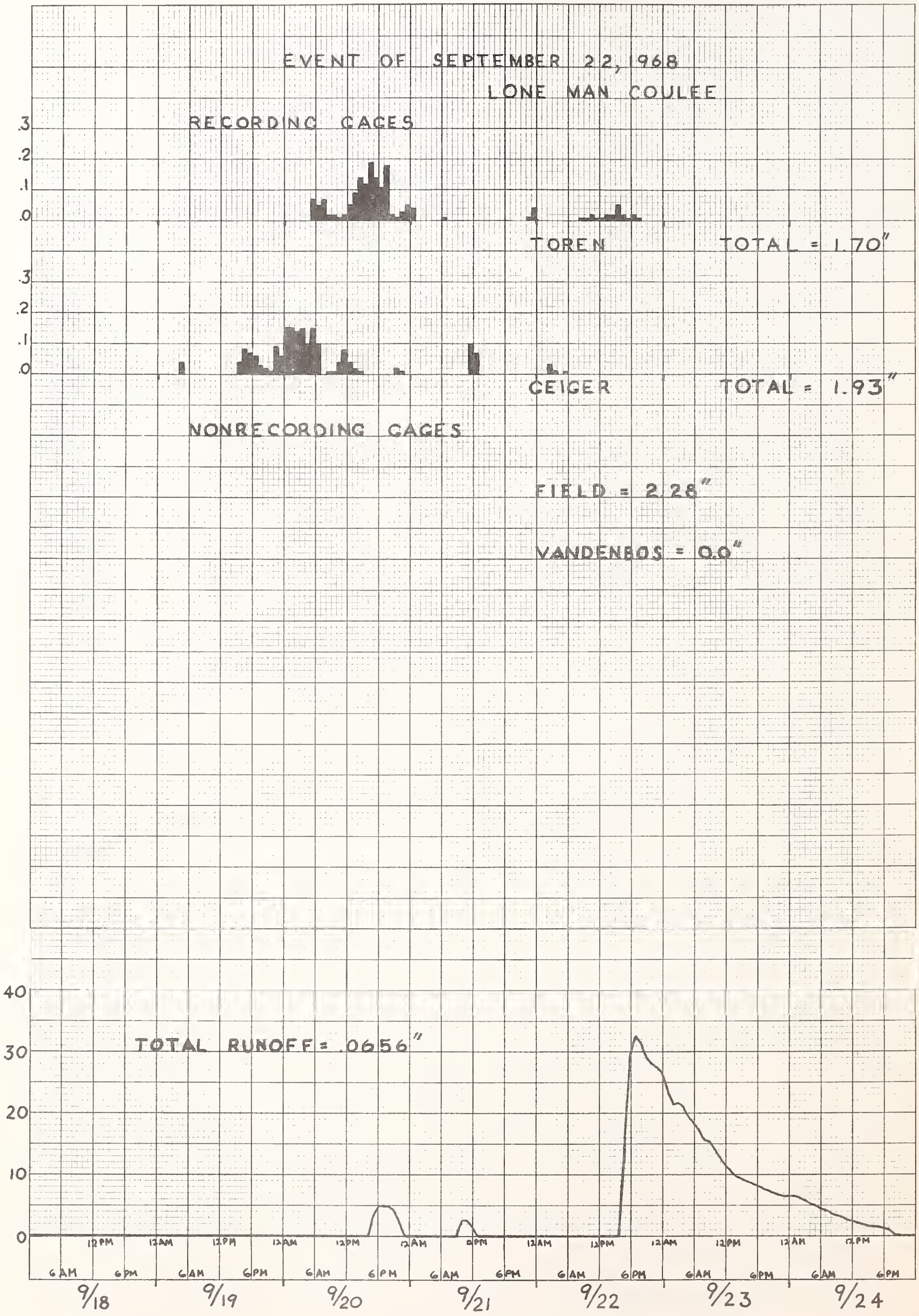

LONEMAN COULEE
EVENT OF MAY 7, 1967
TOTAL RUNOFF = 0.26
CONVERSION FACTOR = 3.846
UNIT HYDROGRAPH
DISCHARGE CFS
500
475
450
425
400
375
350
325
300
275
250
225
200
175
150
125
100
75
50
25
0
UNIT HYDROGRAPH
HYDROGRAPH
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
12PM
12AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
5/6
5/7
5/8
5/9
5/10
5/11
5/12
5/13

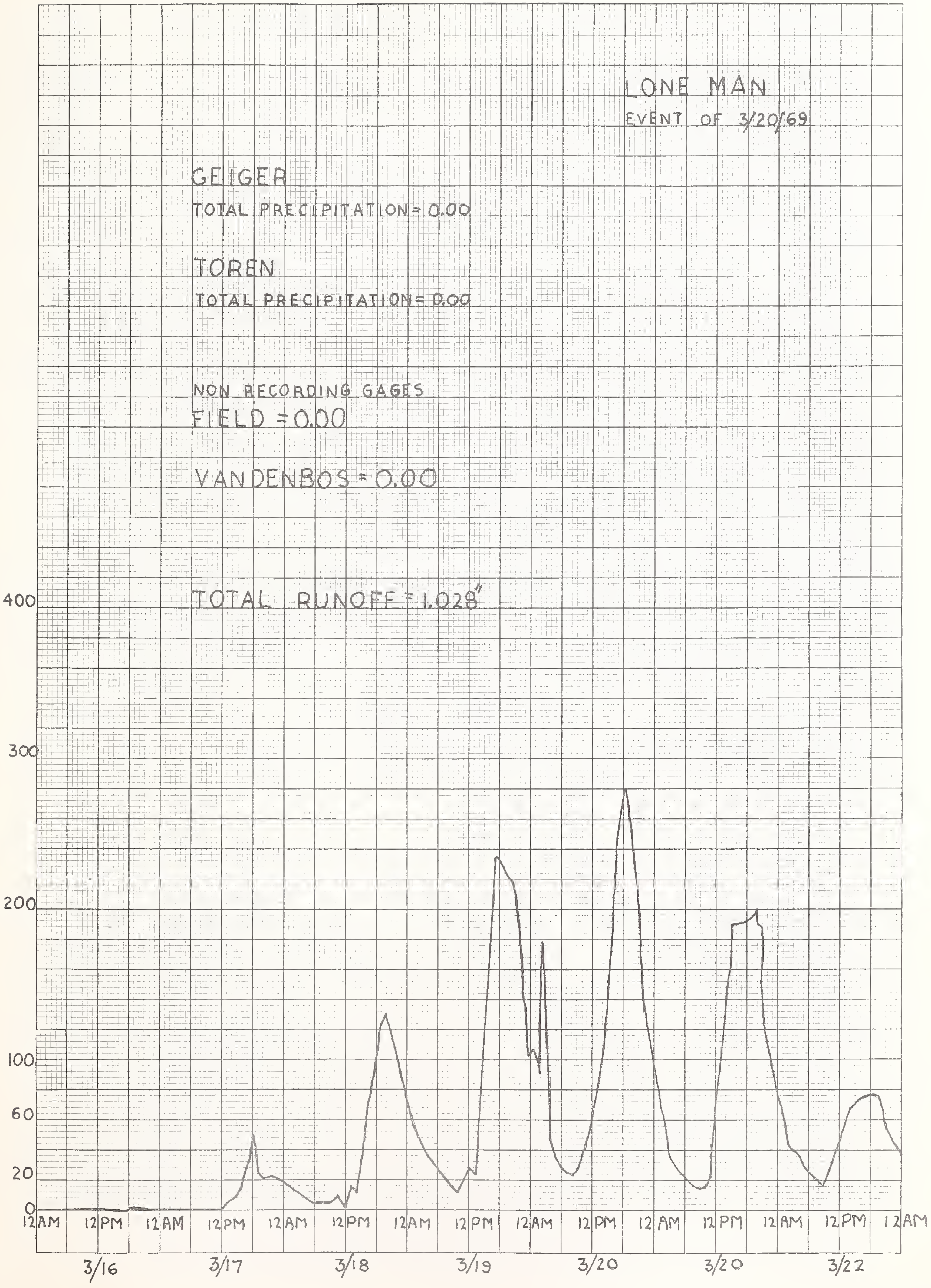
EVENT OF MAY 14, 1967
LONE MAN
DISCHARGE DUE TO SNOW FALL FROM PERIOD MAY 9, 1967 TO MAY 12, 1967
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
TOTAL = .16"
GEIGER
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
TOTAL = .09"
TOREN
NON-RECORDING RAIN GAGES
FIELD = .42"
VANDEN BOS = .27"
TOTAL RUN OFF = .13"
DISCHARGE, CFS
100
90
80
70
60
50
40
30
20
10
0
12AM
12AM
12AM
12PM
12AM
12AM
12AM
12PM
12AM
12AM
12PM
12AM
12AM
12PM
12AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
5/11
5/12
5/13
5/14
5/15
5/16
5/17
5/18
1967


EVENT OF MAY 30, 1967
LONE MAN
TOTAL PRECIPITATION = 1.78"
GEIGER
TOTAL PRECIPITATION = 1.49"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 2.14"
VANDEN BOS = 0.98"
TOTAL RUNOFF = 0.03"
RAINFALL INCHES
.5
.4
.3
.2
.1
0
DISCHARGE C.F.S.
100
90
80
70
60
50
40
30
20
10
0
12 AM
6 PM
12 PM
6 AM
5/29
5/30
5/31
6/1
6/2
6/3
6/4
6/5
1967


EVENT OF JUNE 10, 1967
LONE MAN
TOTAL PRECIPITATION = 1.65"
GEIGER
TOTAL PRECIPITATION = 1.51"
TOREN
NON-RECORDING RAIN GAGES
FIELD = 1.83
VANDEN BOS = 1.74
TOTAL RUN OFF = 0.20"
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
.4
.3
.2
.1
0
150
140
130
120
110
100
100
90
80
70
60
50
40
30
20
10
0
DISCHARGE C.F.S.
12 AM
12 P.M
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
12 PM
12 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6 PM
6 AM
6/9
6/10
6/11
6/12
6/13
6/14
6/15
6/16
1967


EVENT OF JANUARY 23, 1968
LONE MAN
TOTAL PRECIPITATION = 0.26"
Geiger
TOTAL PRECIPITATION = 0.17"
Toren
NON-RECORDING RAIN GAGES
FIELD = 0.28"
VANDEN BOS = 0.02"
TOTAL RUN OFF = .0904
RAIN FALL INCHES
.5
.4
.3
.2
.1
0
DISCHARGE C.F.S
100
90
80
70
60
50
40
30
20
10
0
12 AM
6 PM
12 PM
6 AM
1/21
1/22
1/23
1/24
1/25
1/26
1968


EVENT OF SEPTEMBER 22, 1968
LONE MAN COULEE
RECORDING GAGES
.3
.2
.1
.0
TOREN
TOTAL = 1.70"
.3
.2
.1
.0
GEIGER
TOTAL = 1.93"
NONRECORDING GAGES
FIELD = 2.28"
VANDENBOS = 0.0"
40
30
20
10
0
TOTAL RUNOFF = .0656"
12PM
12AM
12PM
12AM
12PM
12AM
6PM
12AM
12PM
12AM
12PM
12AM
12PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
6AM
6PM
9/18
9/19
9/20
9/21
9/22
9/23
9/24



LONE MAN
EVENT OF 3/20/69

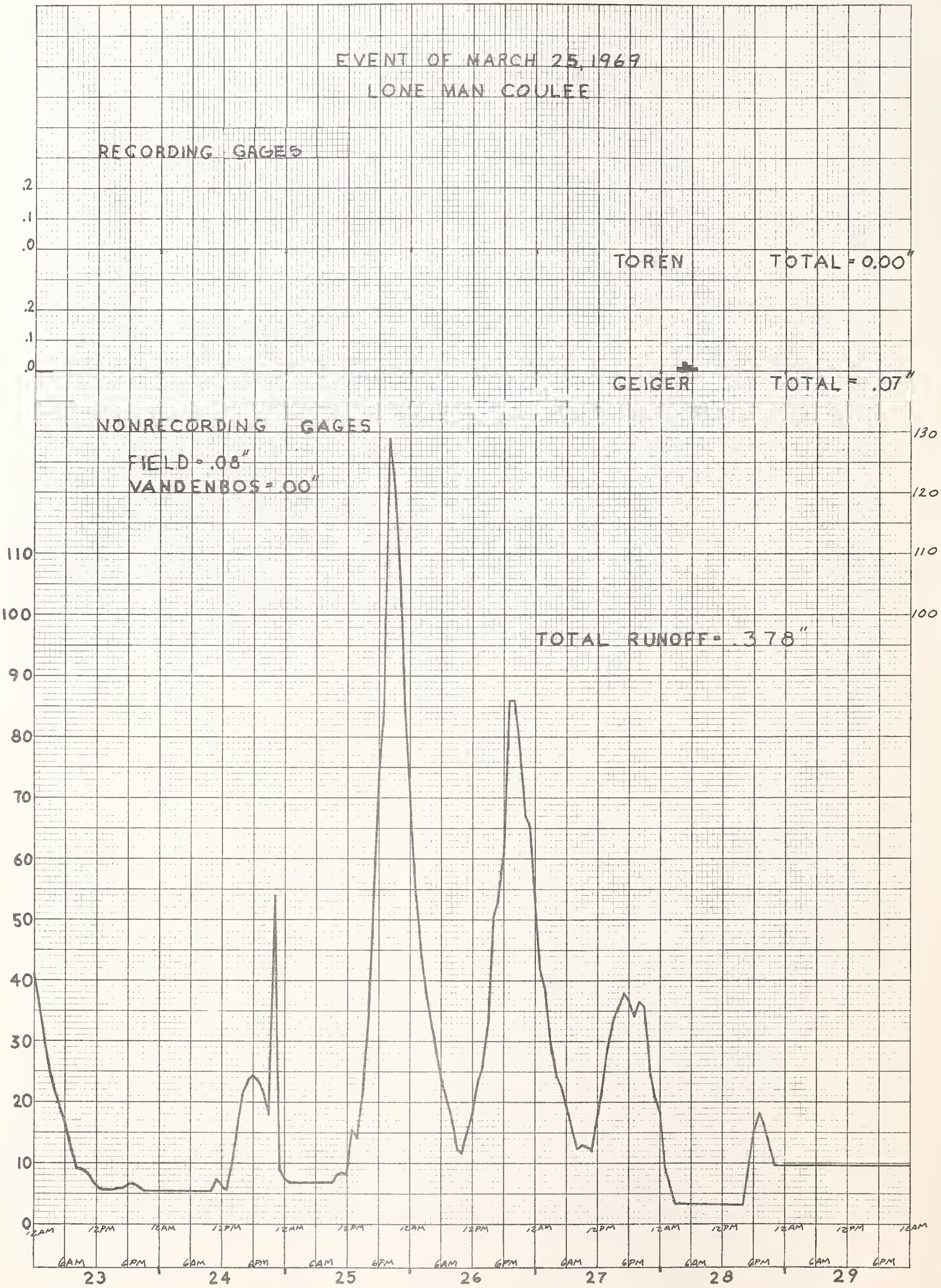
GEIGER
TOTAL PRECIPITATION = 0.00

TOREN
TOTAL PRECIPITATION = 0.00

NON RECORDING GAGES
FIELD = 0.00

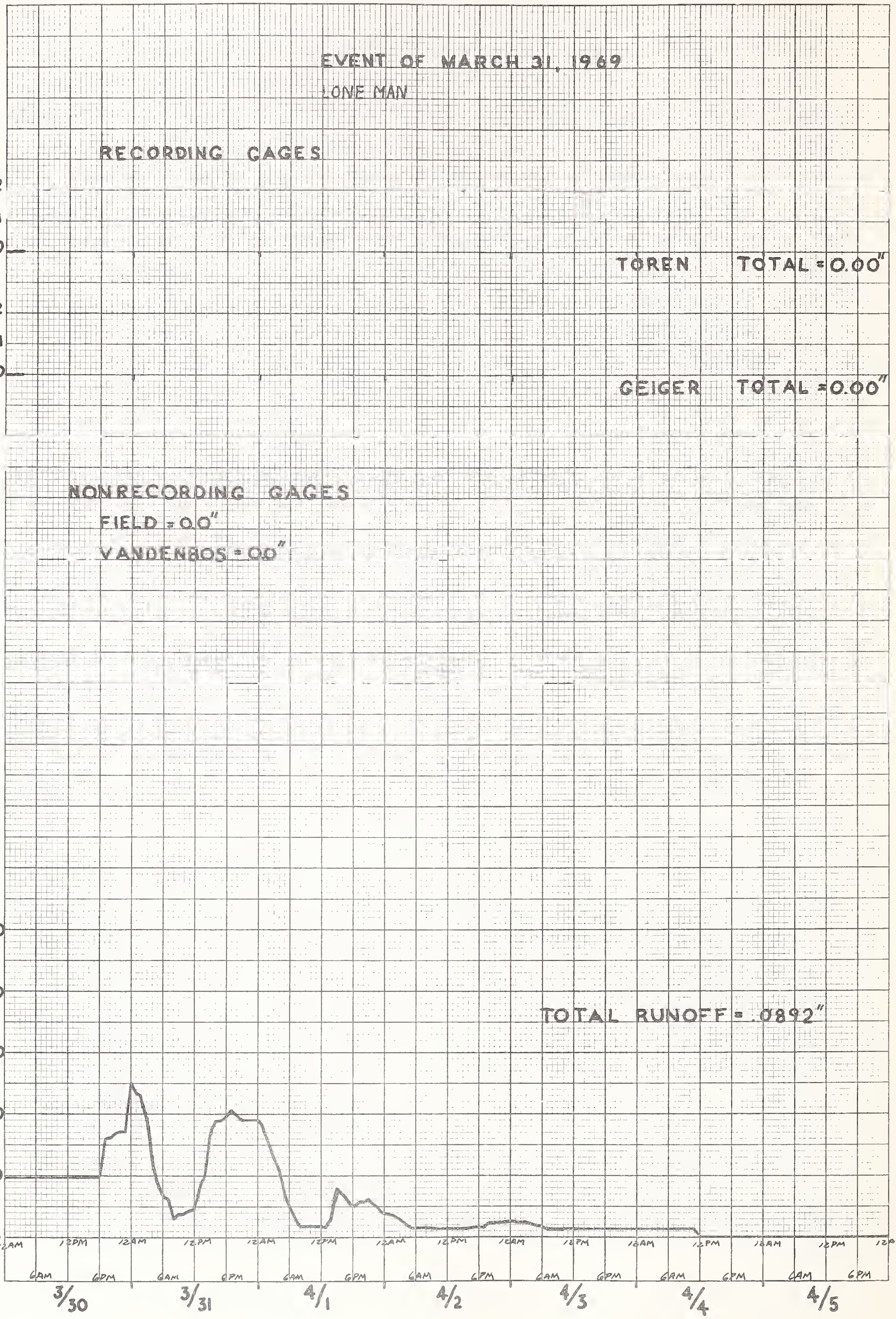
VANDENBOS = 0.00

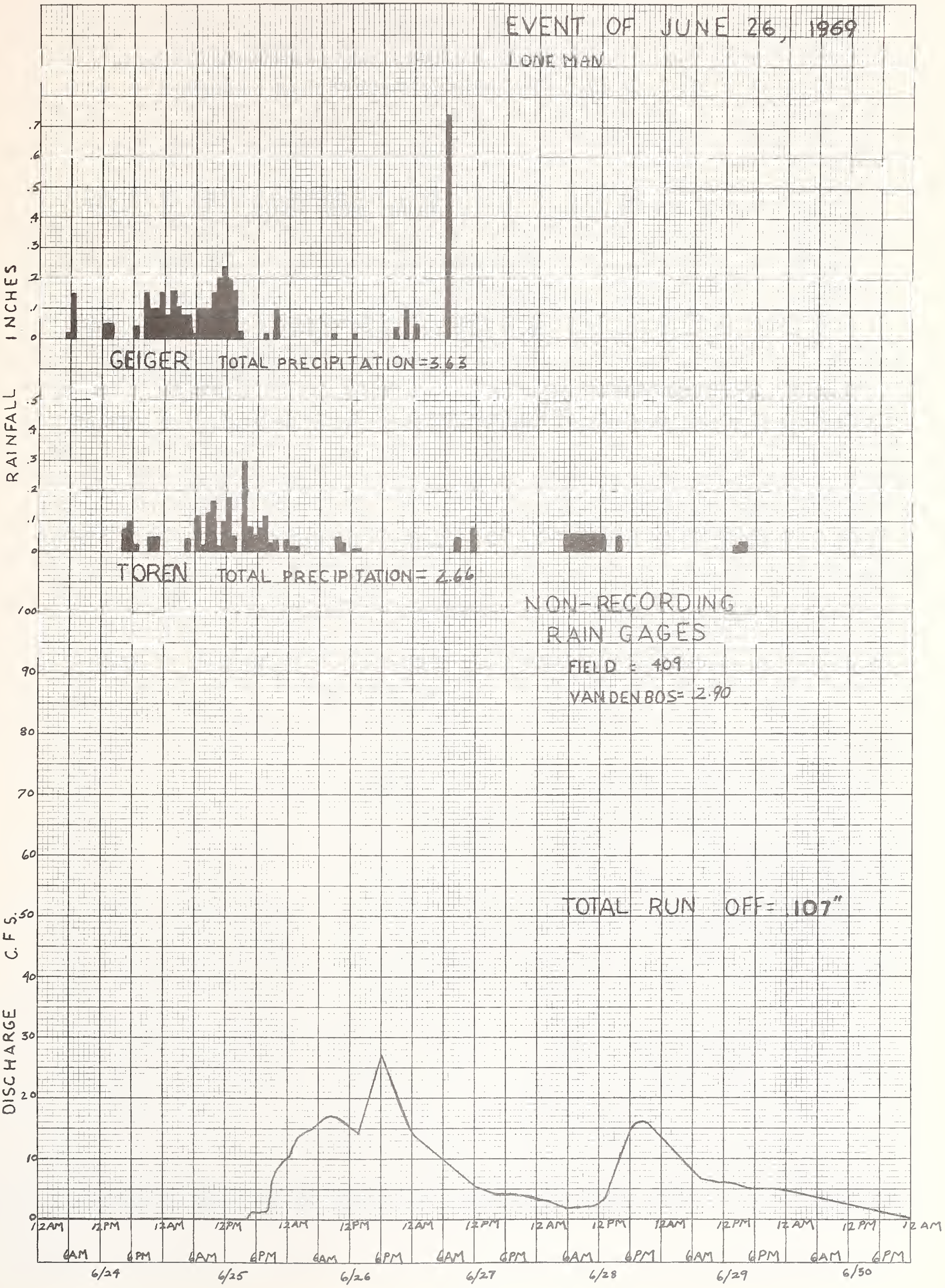
TOTAL RUNOFF = 1.028"


EVENT OF MARCH 25, 1969
LONE MAN COULEE

EVENT OF MARCH 31, 1969

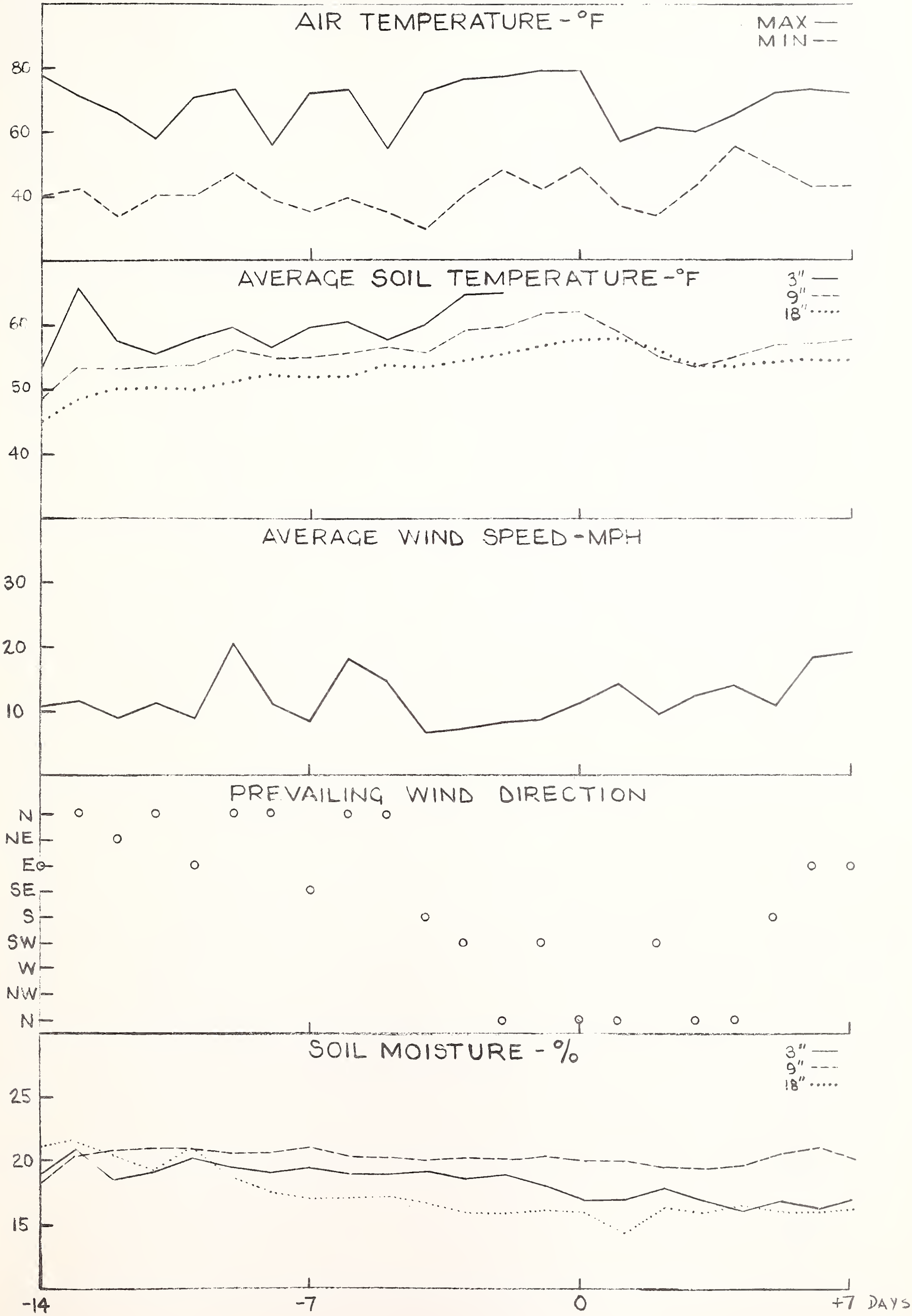
LONE MAN



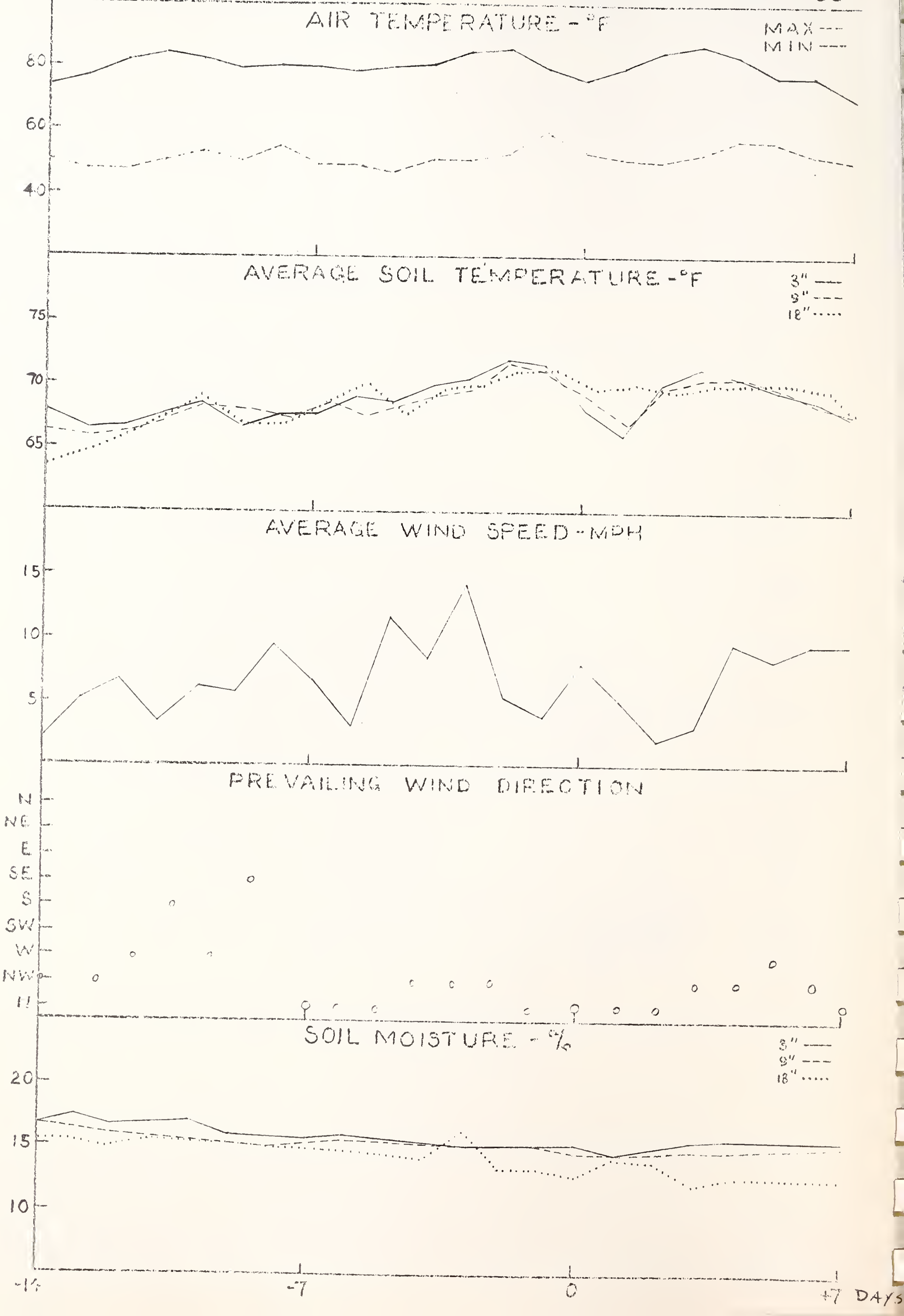

EVENT OF JUNE 26, 1969
LONE MAN
RAINFALL INCHES
.7
.6
.5
.4
.3
.2
.1
0
GEIGER TOTAL PRECIPITATION=3.63
.5
.4
.3
.2
.1
0
TOREN TOTAL PRECIPITATION= 2.66
NON-RECORDING
RAIN GAGES
FIELD = 409
VANDENBOS= 2.90
TOTAL RUN OFF= .107"
DISCHARGE C.F.S.
100
90
80
70
60
50
40
30
20
10
0
12AM
12PM
6AM
6PM
6/24
6/25
6/26
6/27
6/28
6/29
6/50

1969

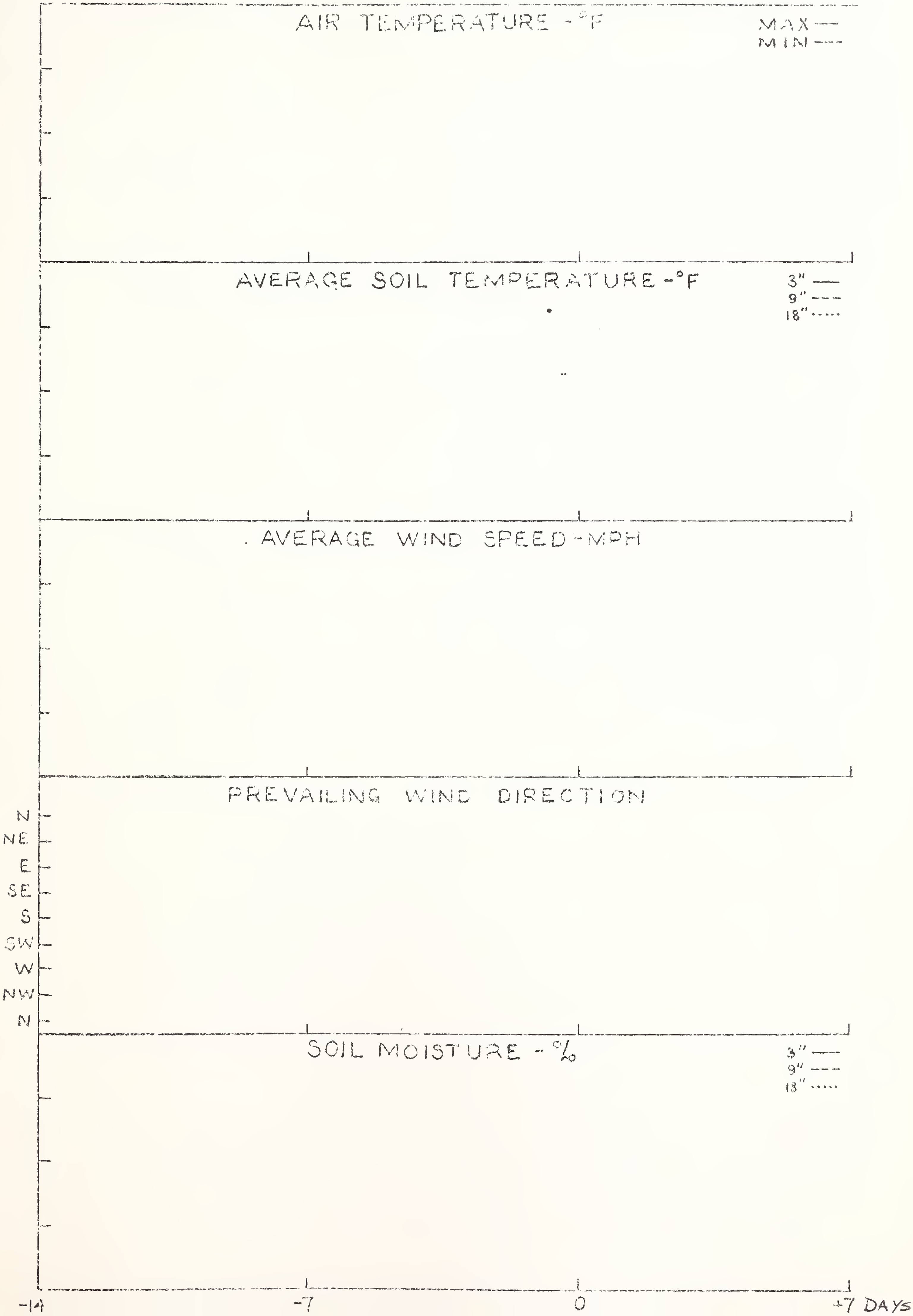
BACON CREEK EVENT OF 6/12/65



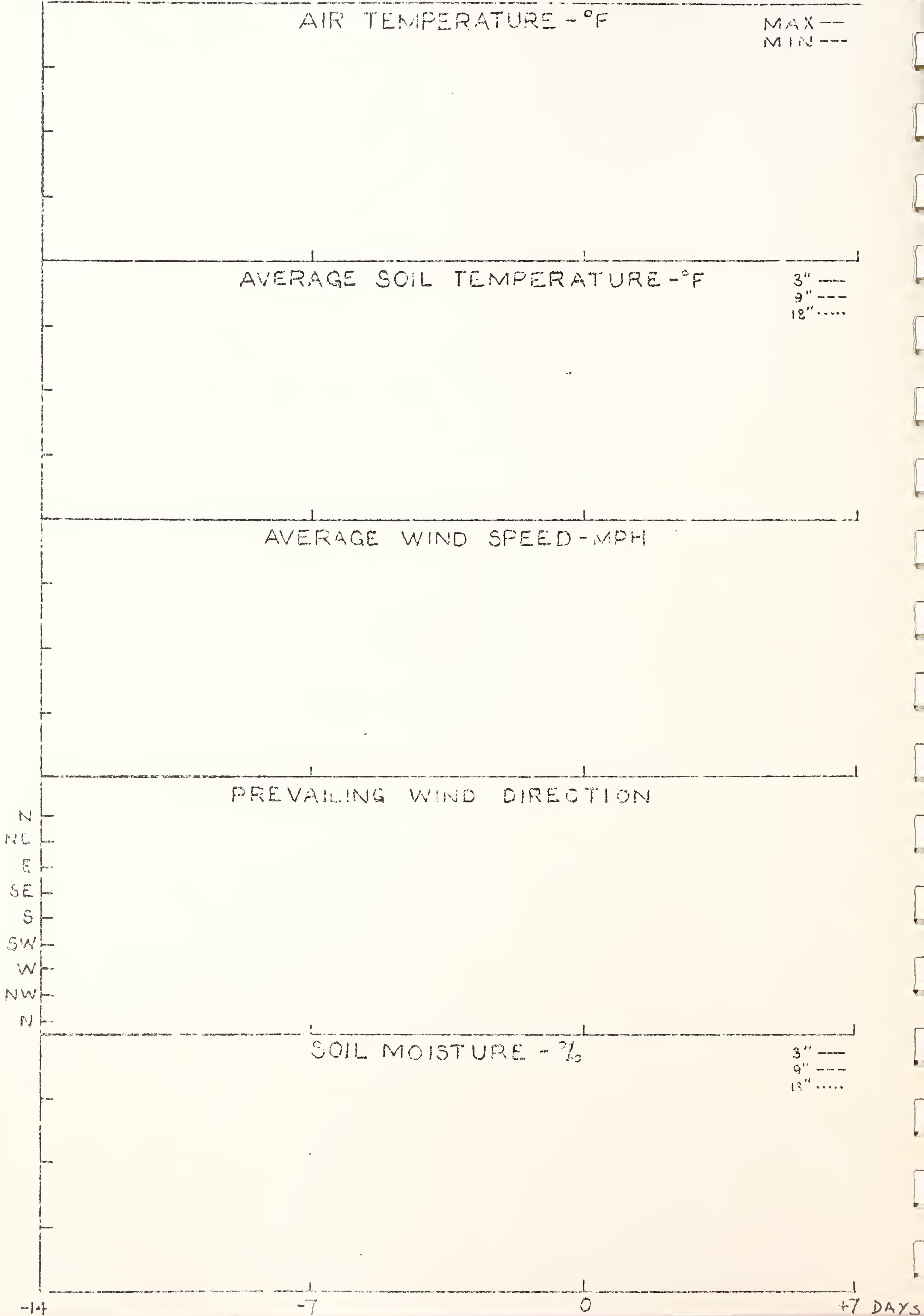
BACON CREEK EVENT OF 7/30/65



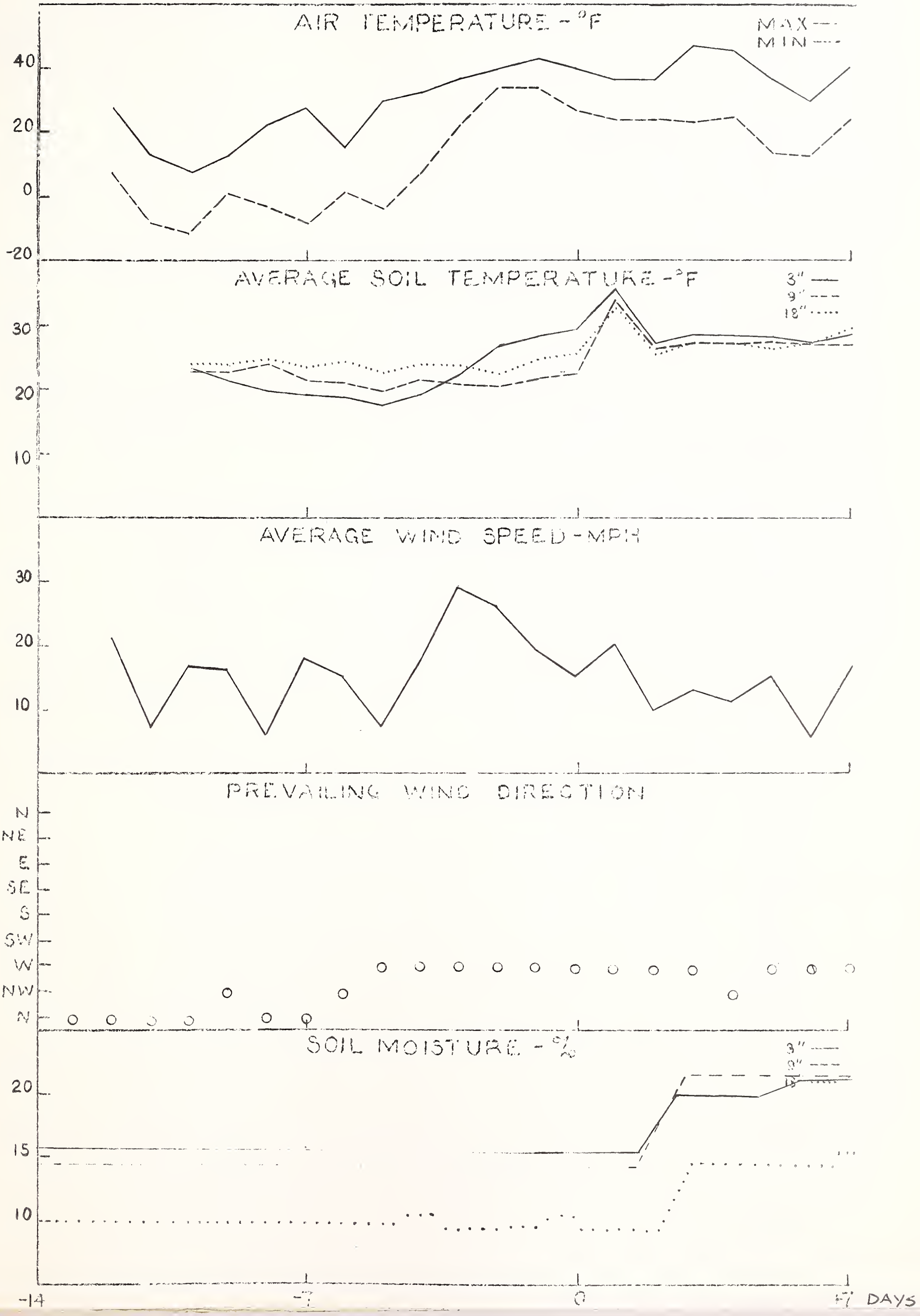
BACON CREEK EVENT OF 6/13/67



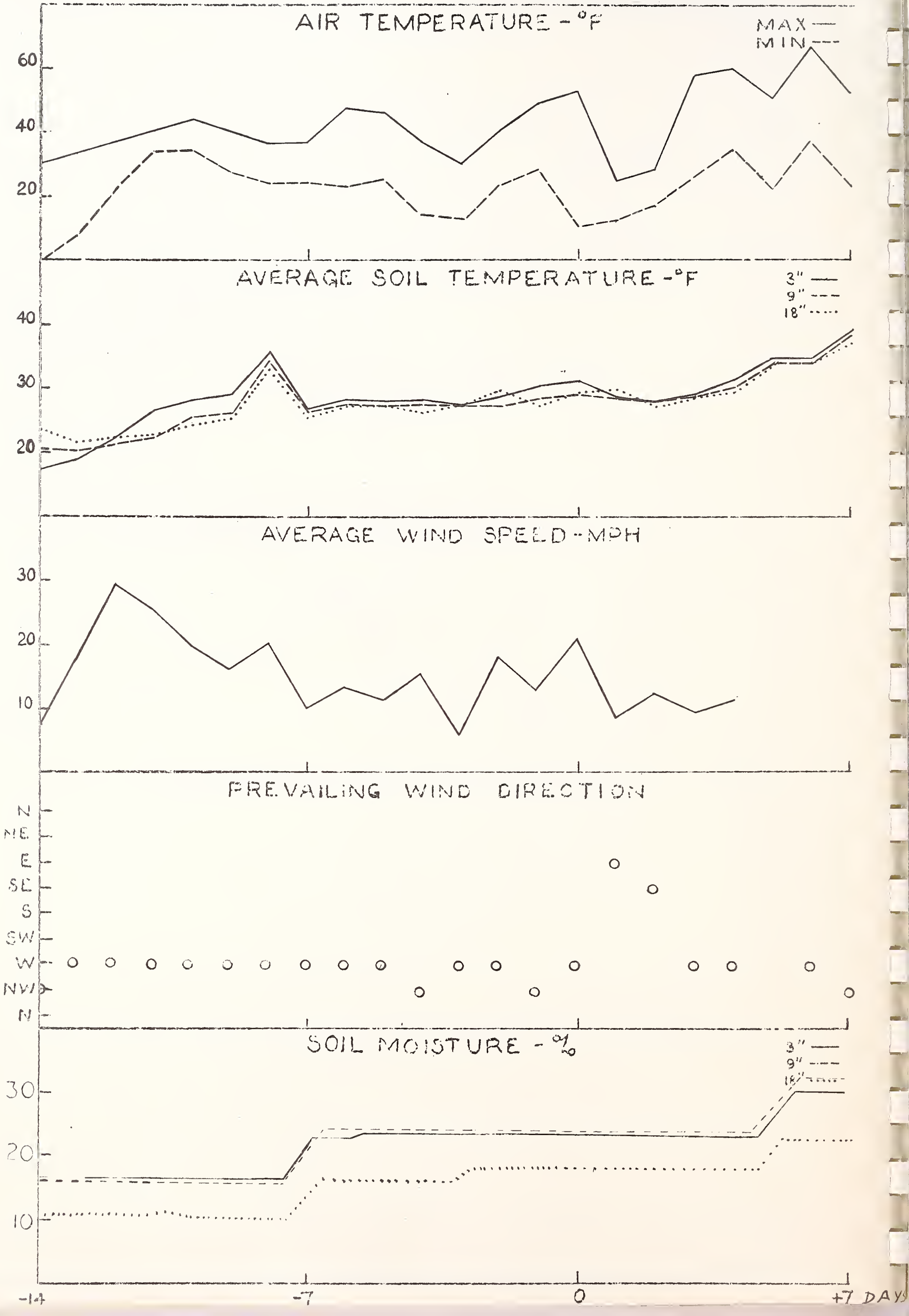
BACON CREEK EVENT OF 7/8/68



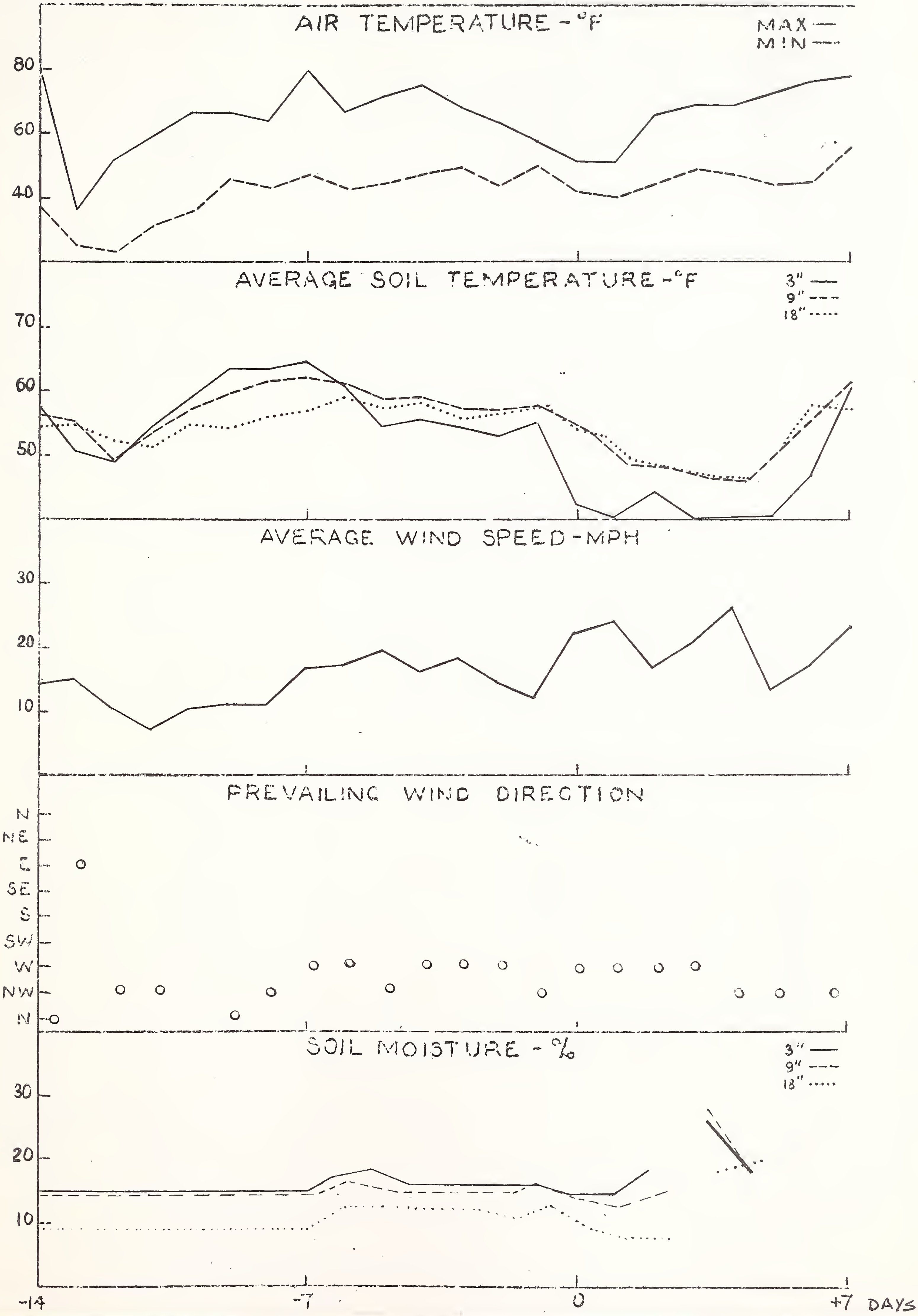
BACON CREEK EVENT OF 3/18/69



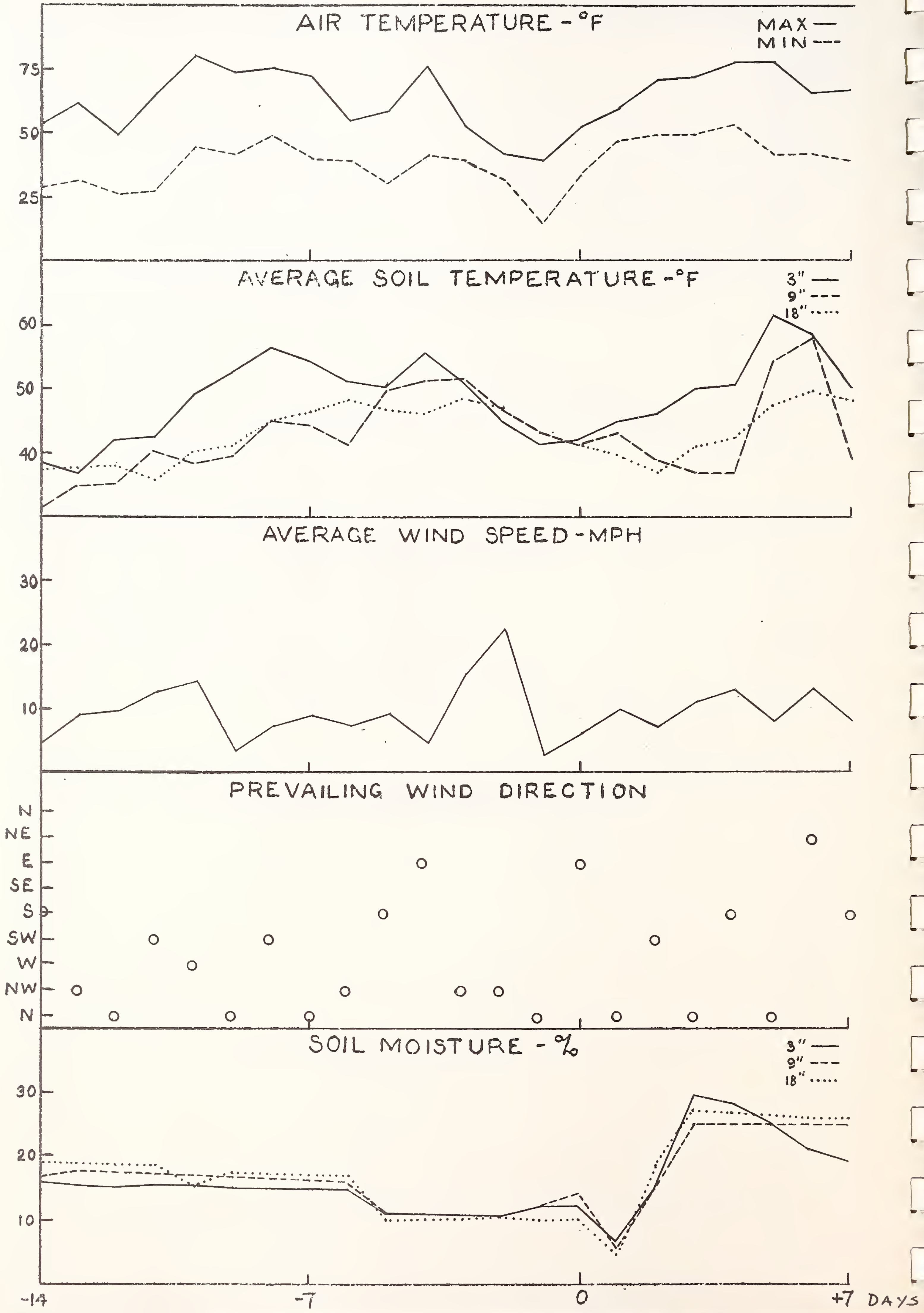
BACON CREEK EVENT OF 3/27/69



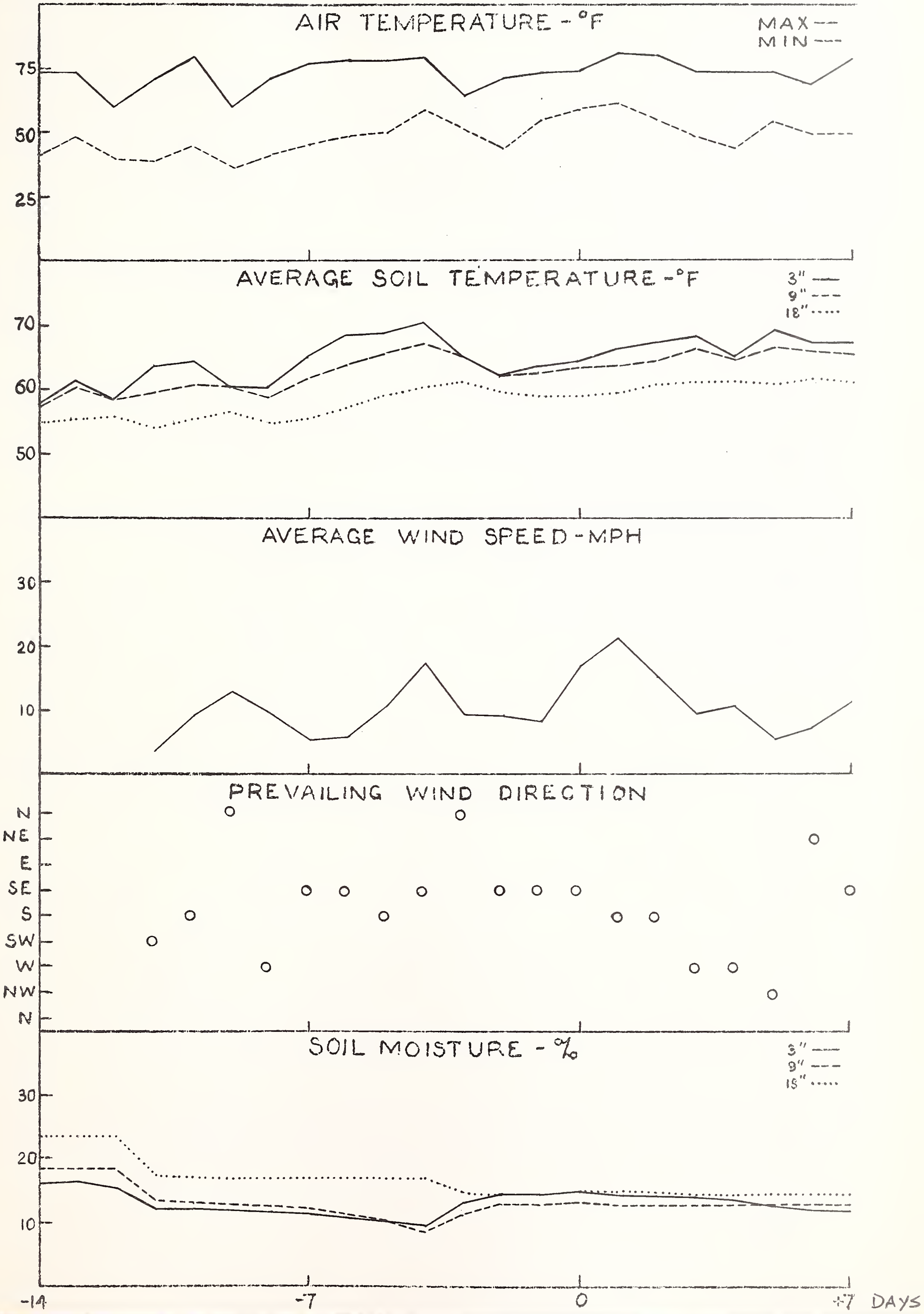
BACON CREEK EVENT OF 6/25/69



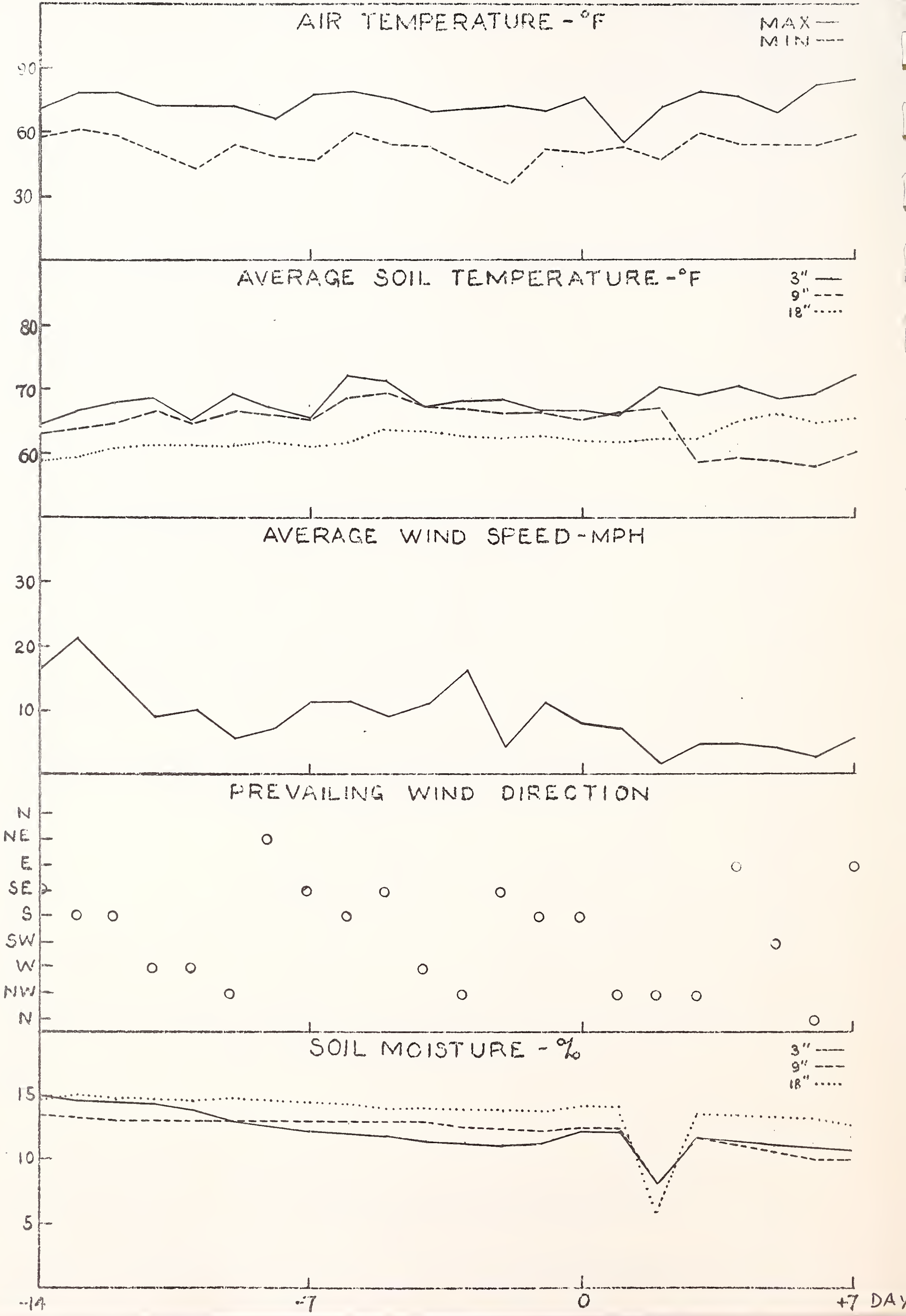
DUCK CREEK EVENT OF 5/8/65



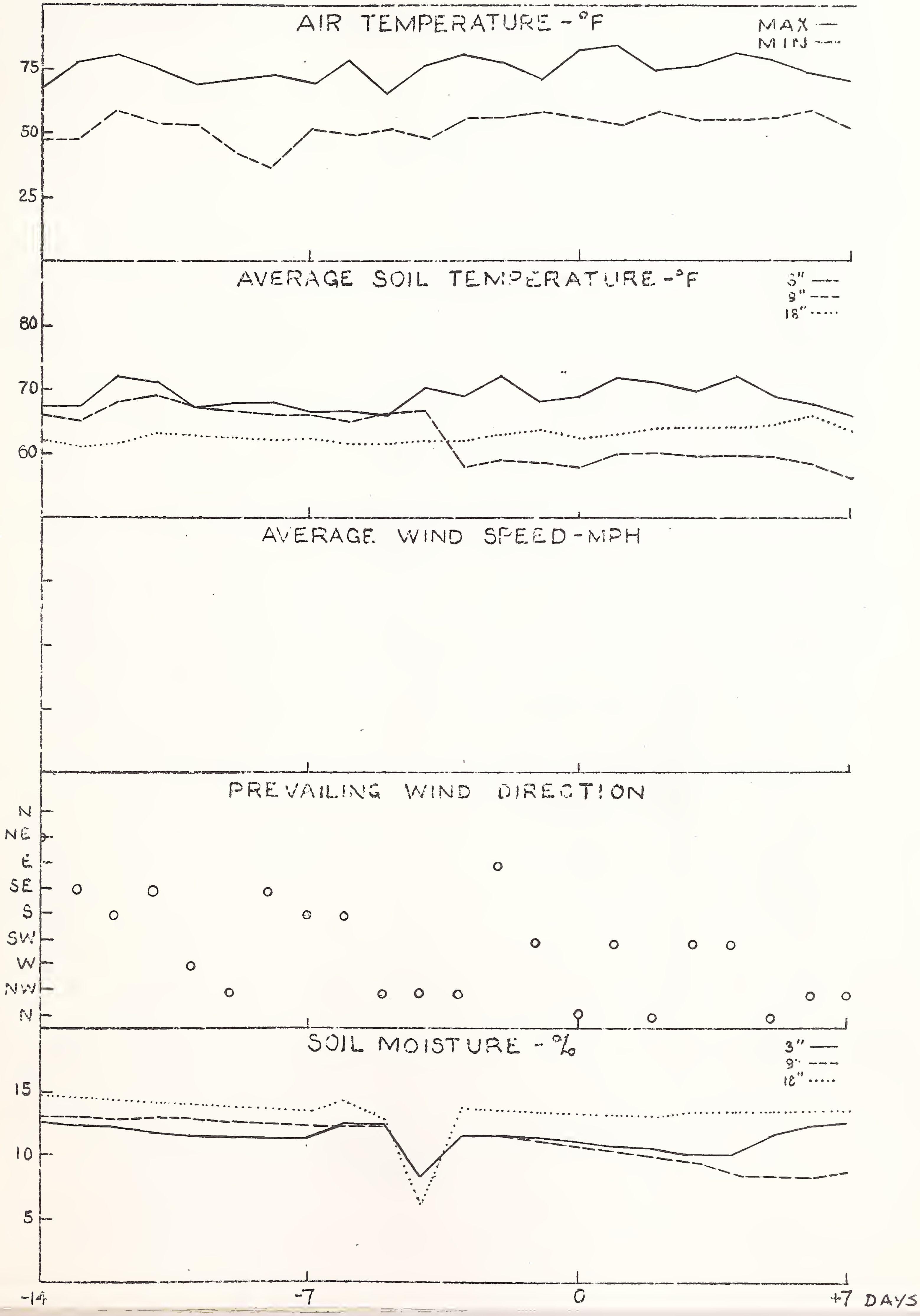
DUCK CREEK EVENT OF 6/16/65



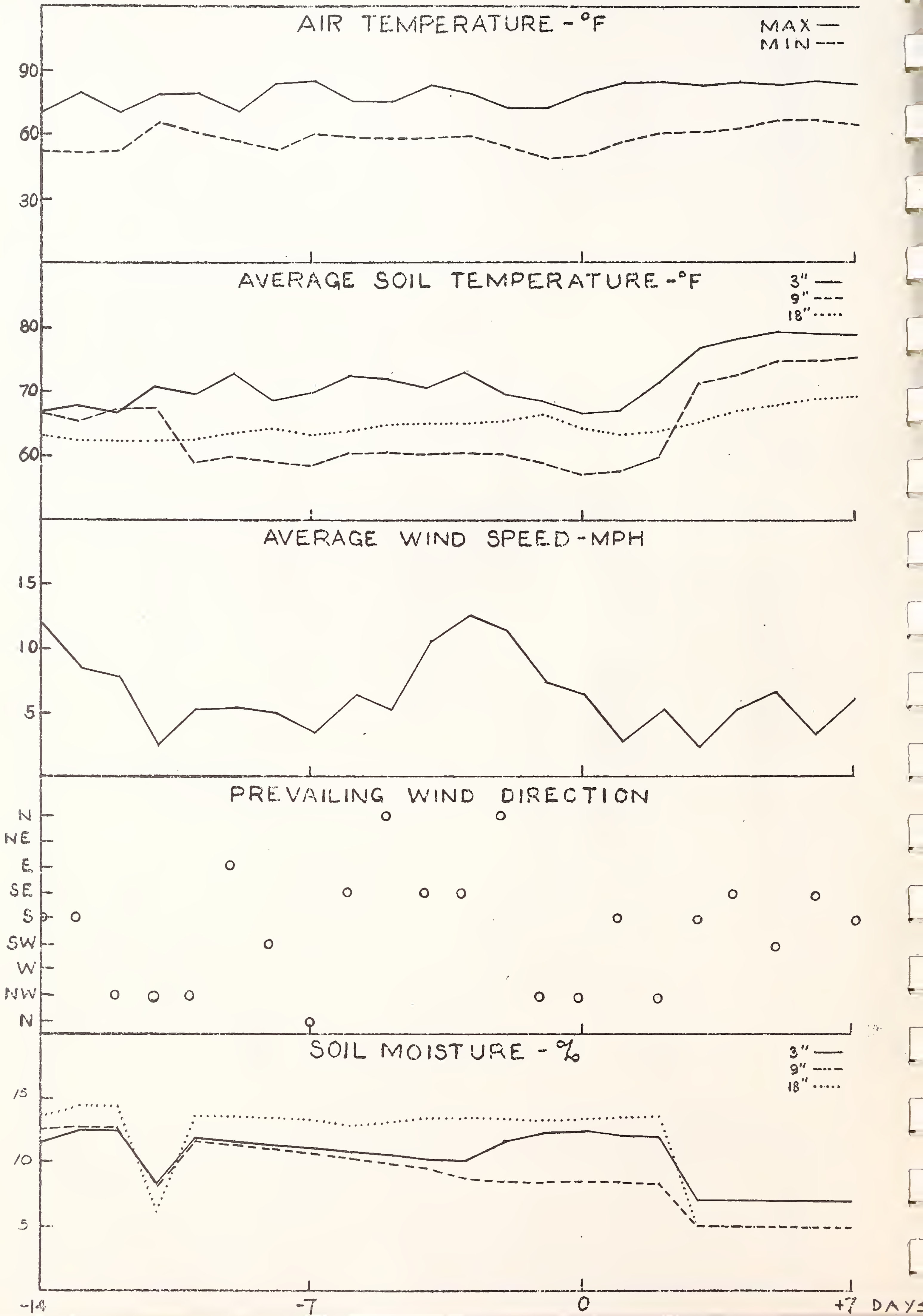
DUCK CREEK EVENT OF 6/30/65



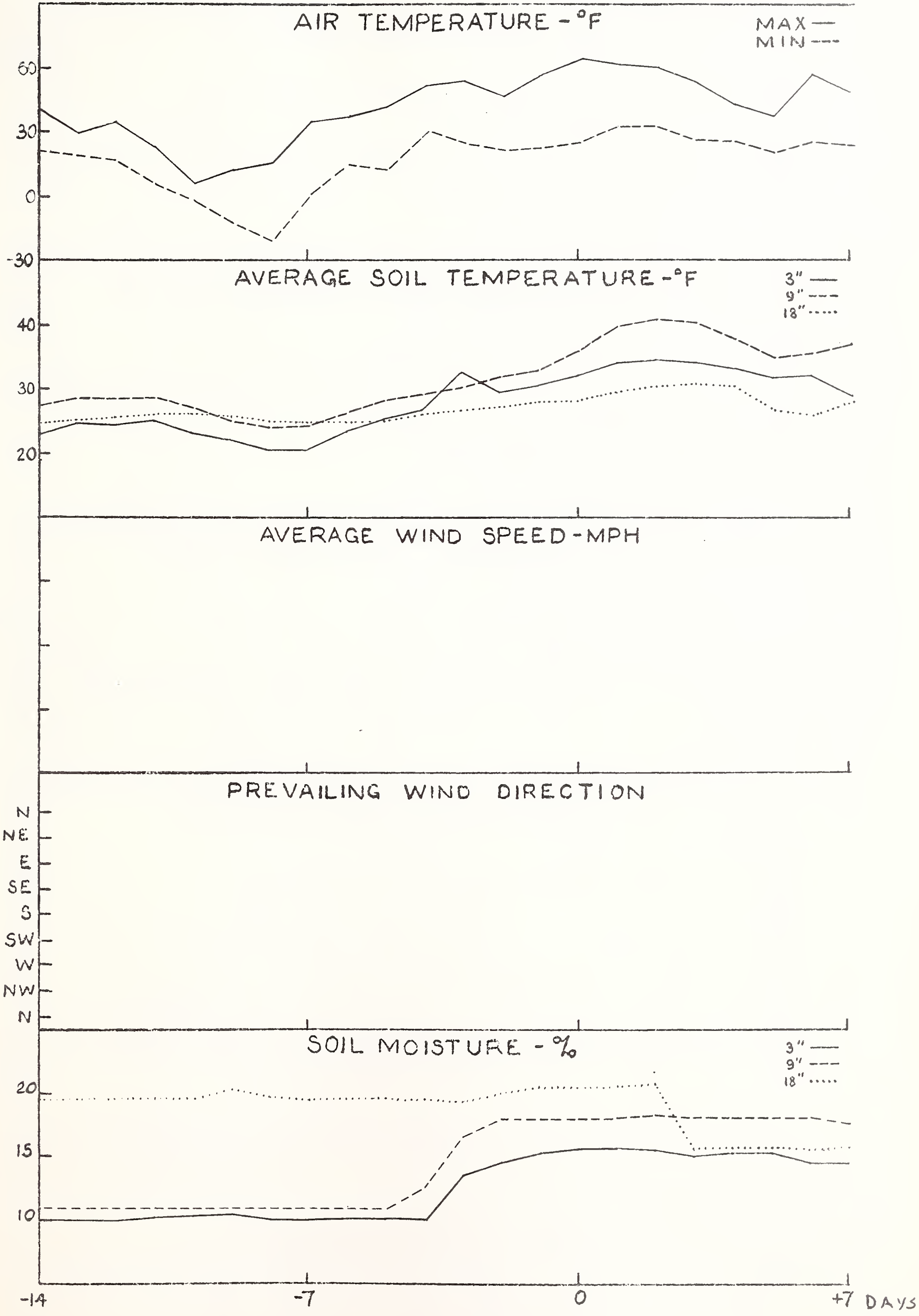
DUCK CREEK EVENT OF 7/6/65



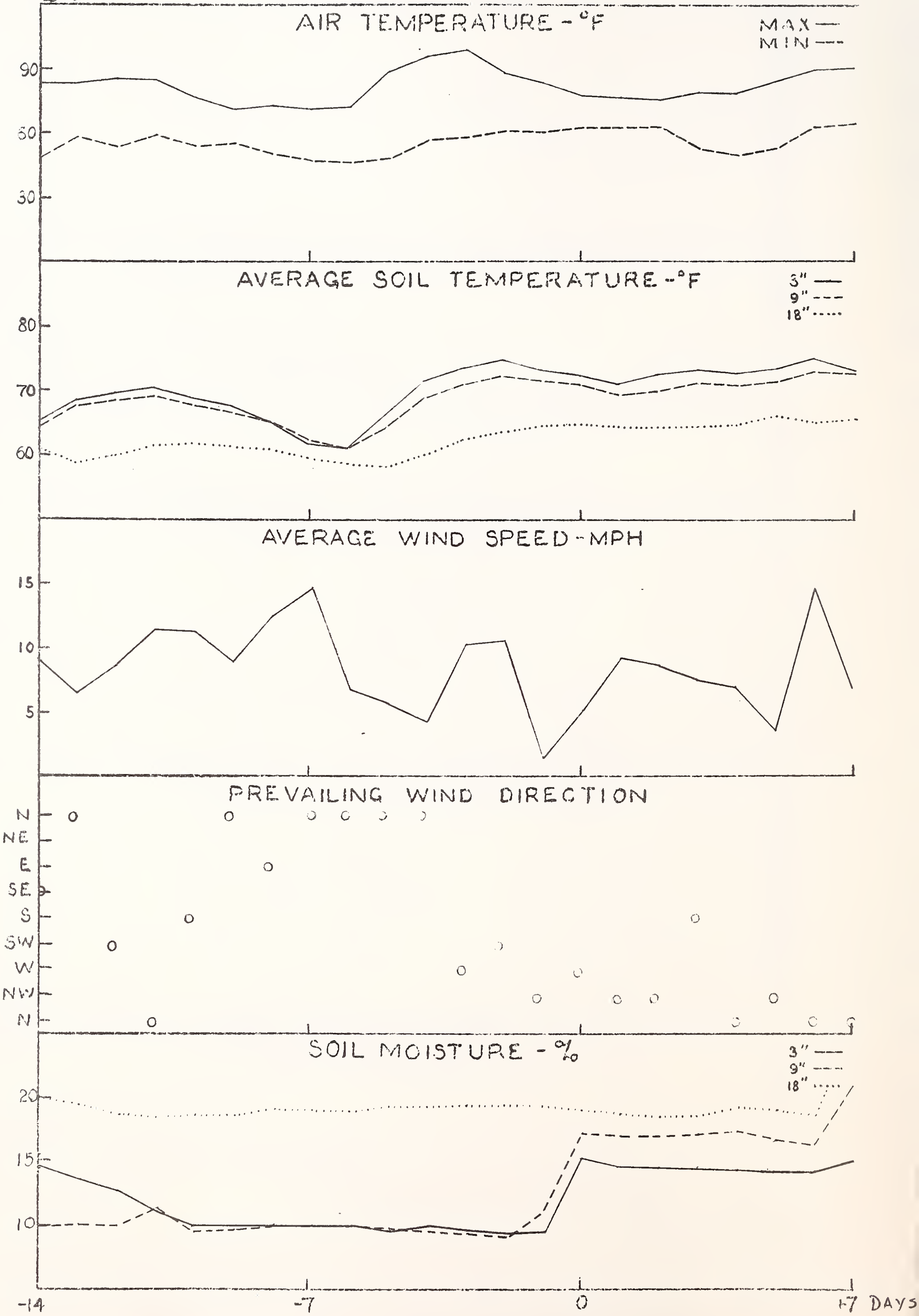
DUCK CREEK EVENT OF 7/13/65



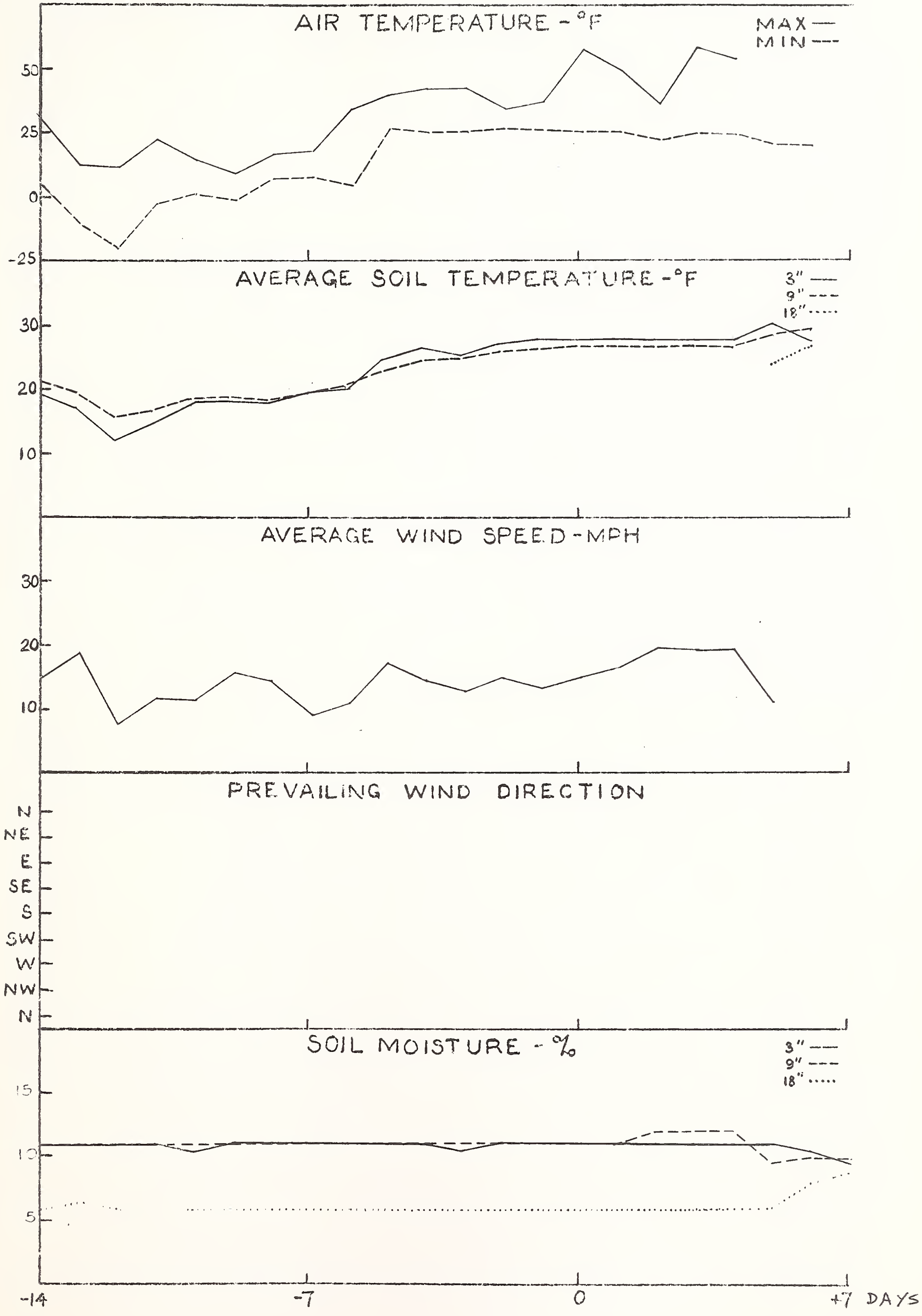
DUCK CREEK EVENT OF 3/13/66



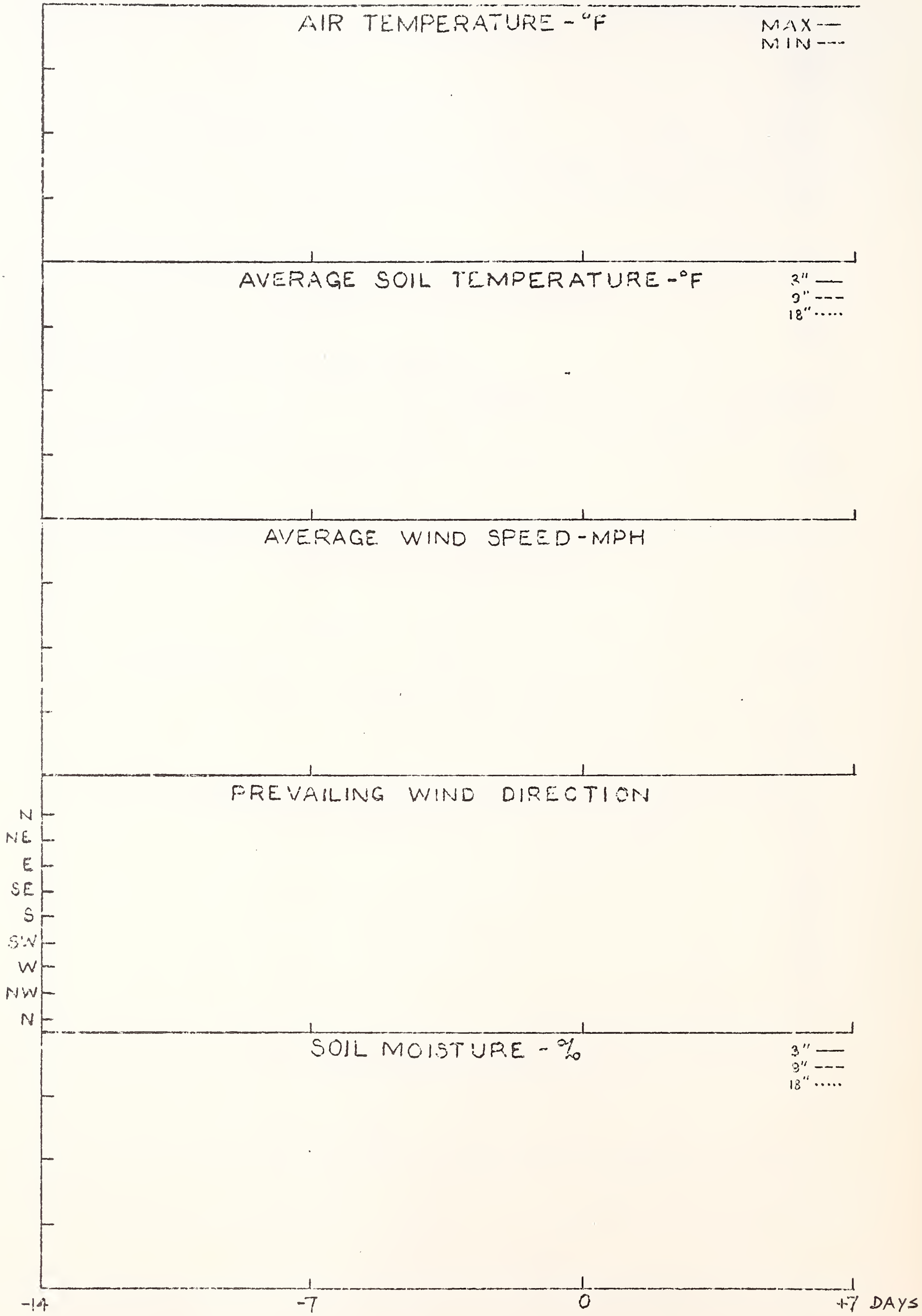
DUCK CREEK EVENT OF 7/1/66



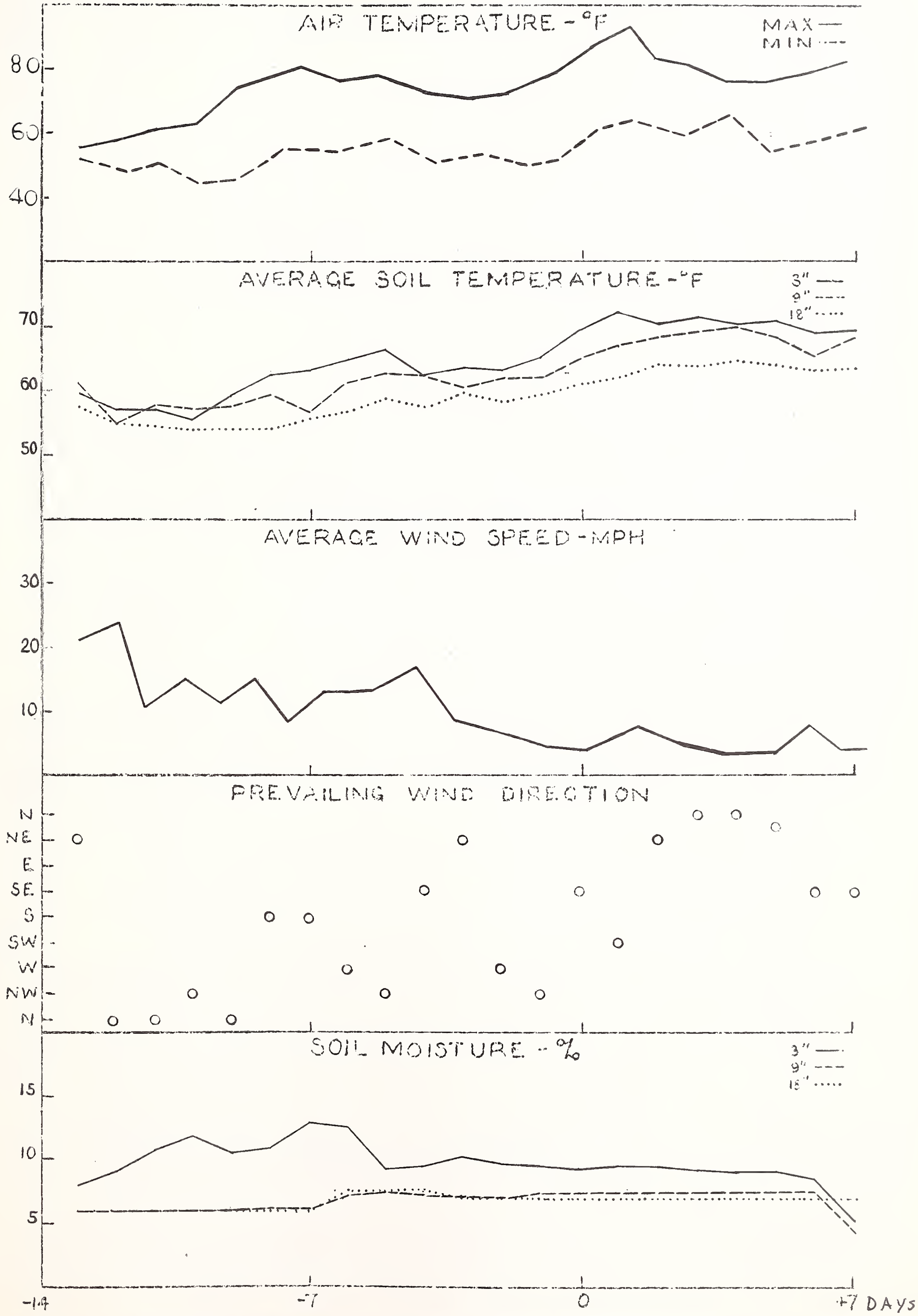
DUCK CREEK EVENT OF 2/29/68



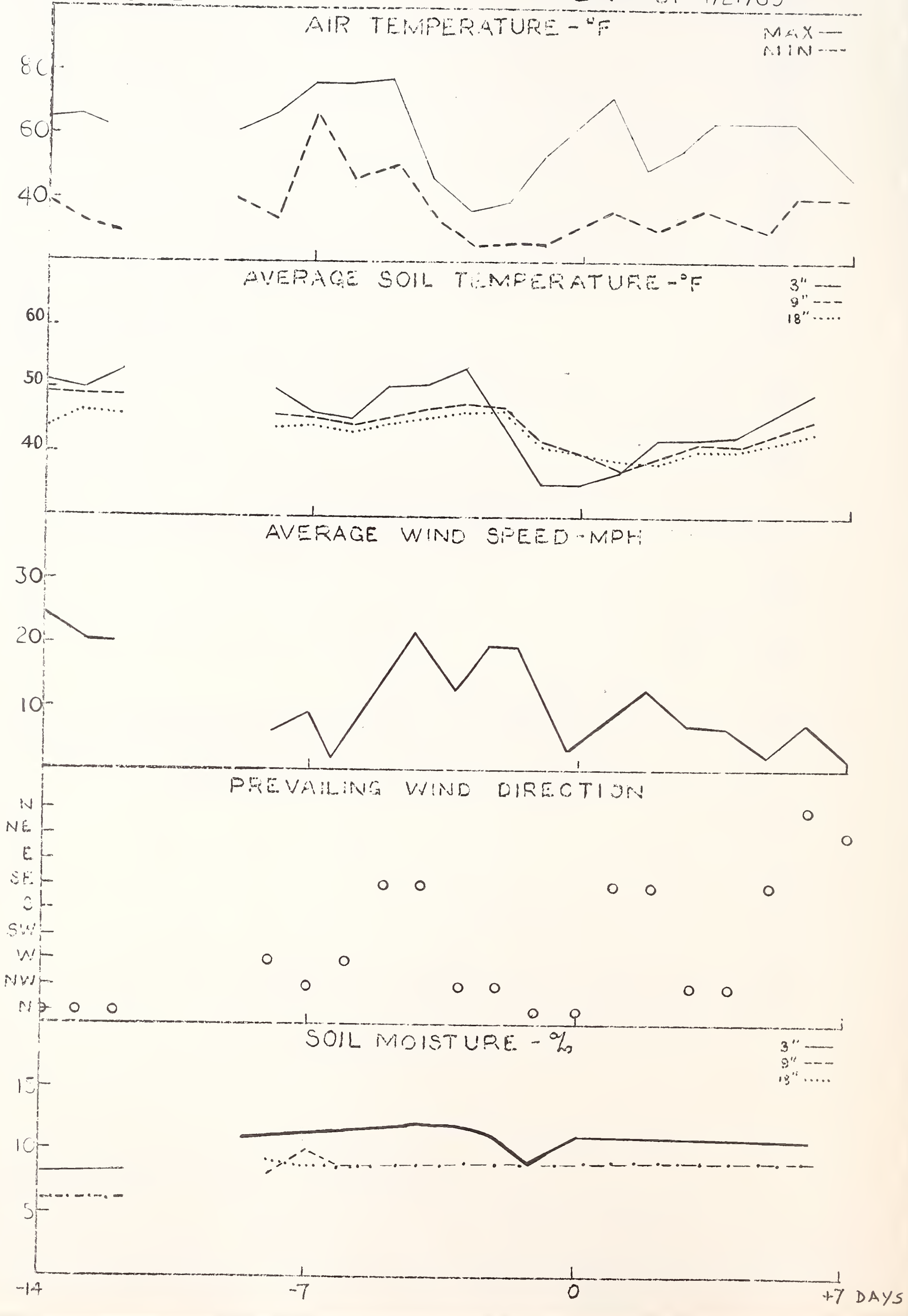
DUCK CREEK EVENT OF 3/18/69



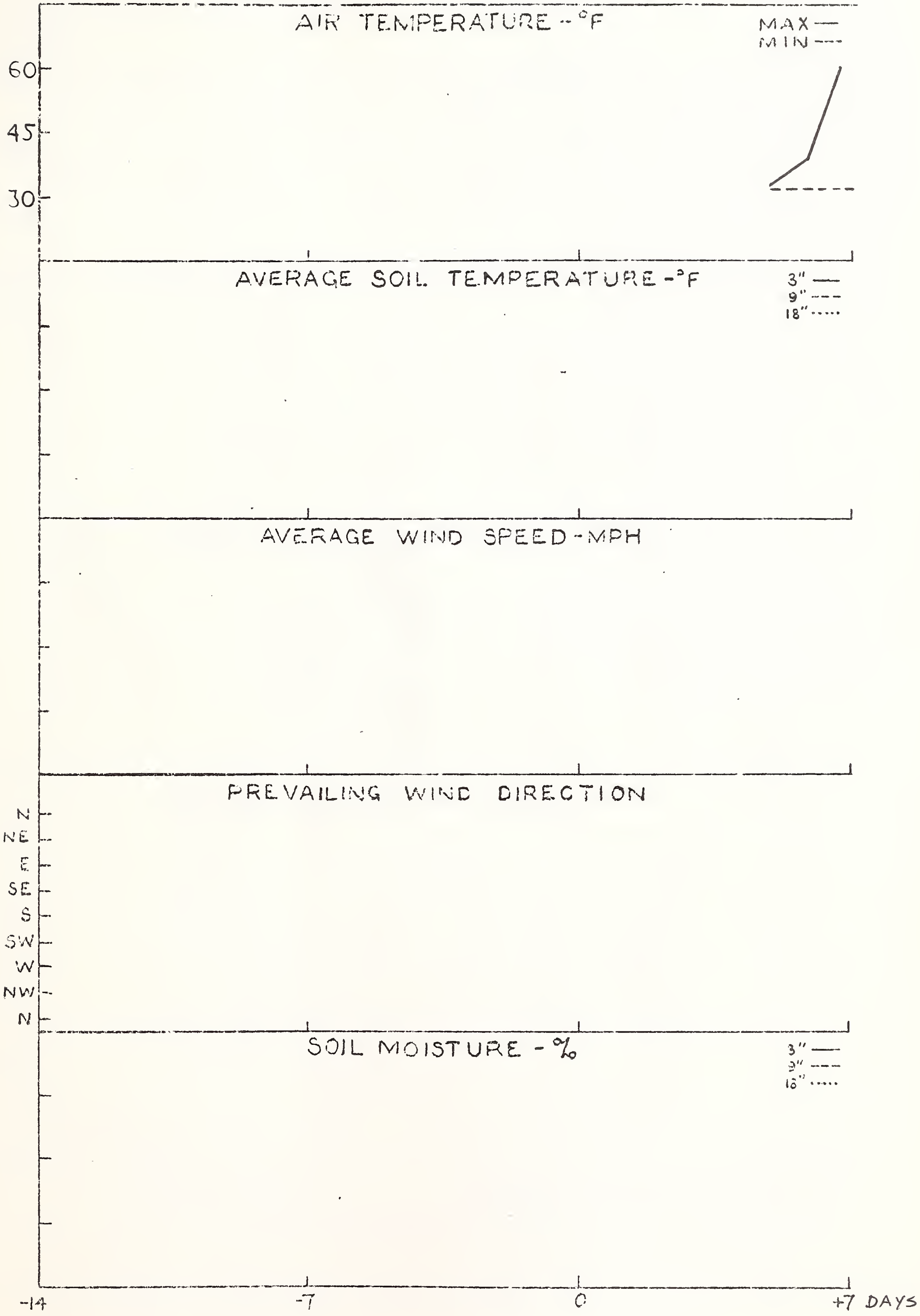
DUCK CREEK EVENT OF 7/8/69



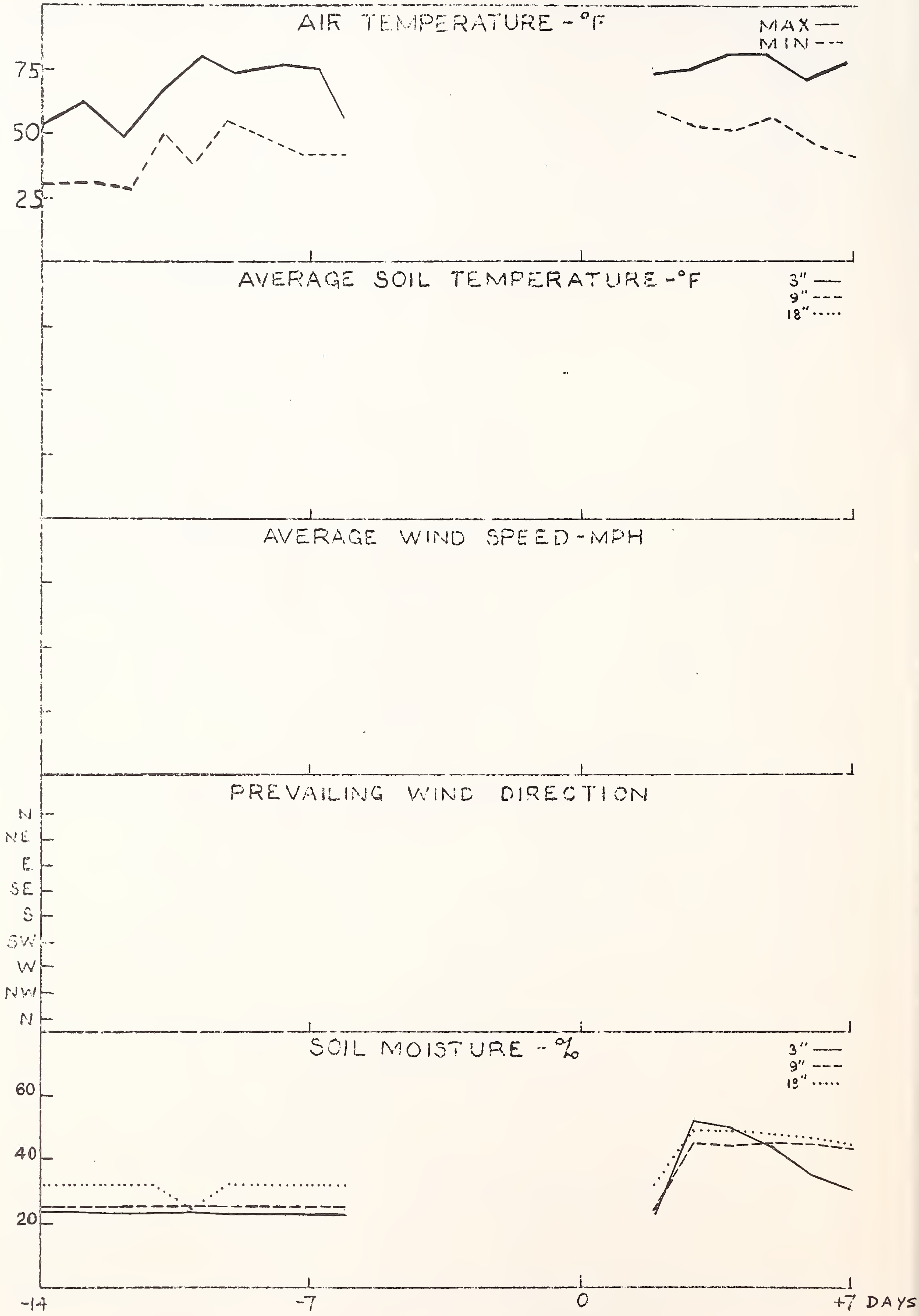
DUCK CREEK EVENT OF 4/27/69



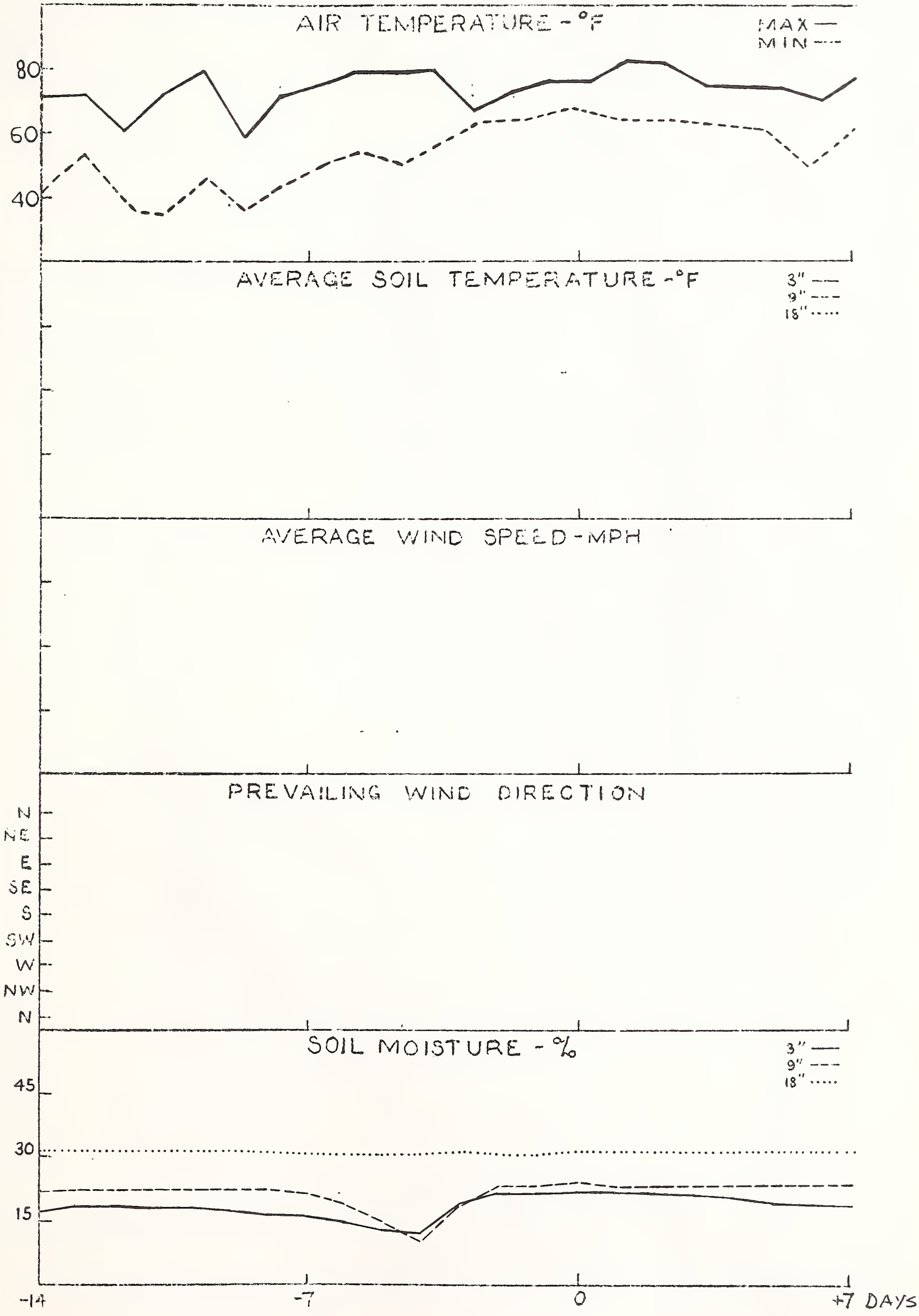
EAST FORK DUCK CREEK EVENT OF 3/30/65



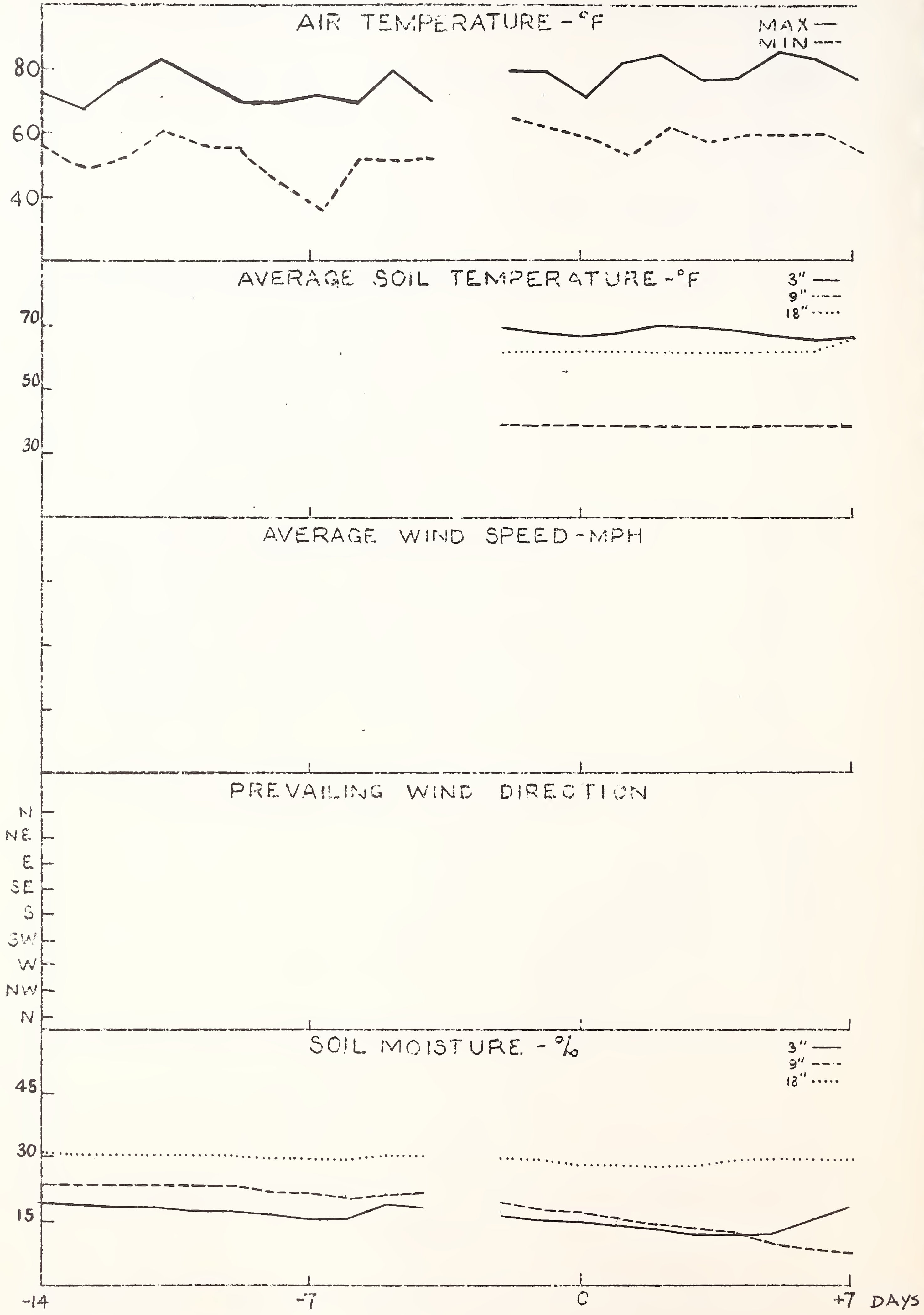
EAST FORK DUCK CREEK EVENT OF 5/8/65



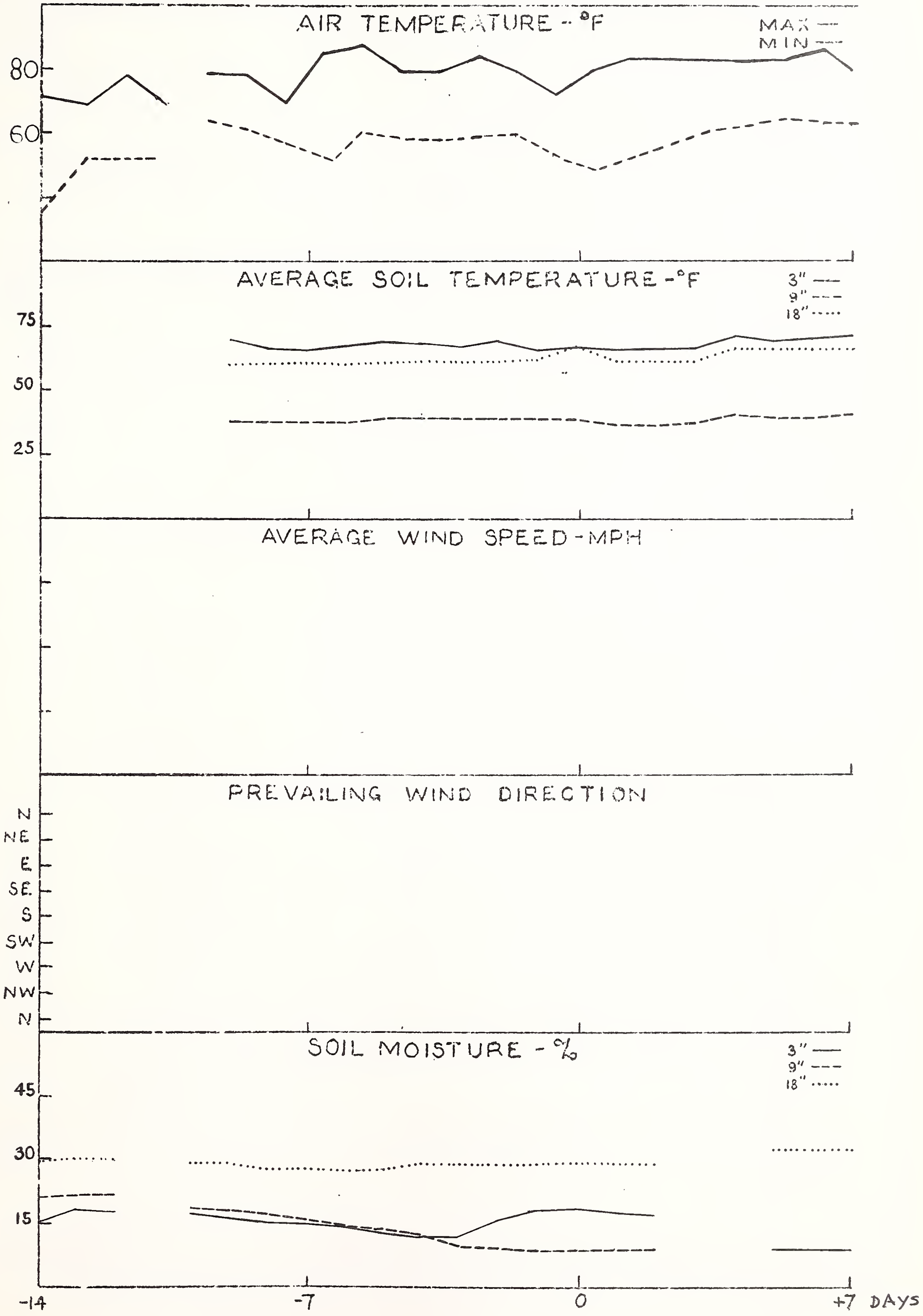
EAST FORK DUCK CREEK EVENT OF 6/16/65



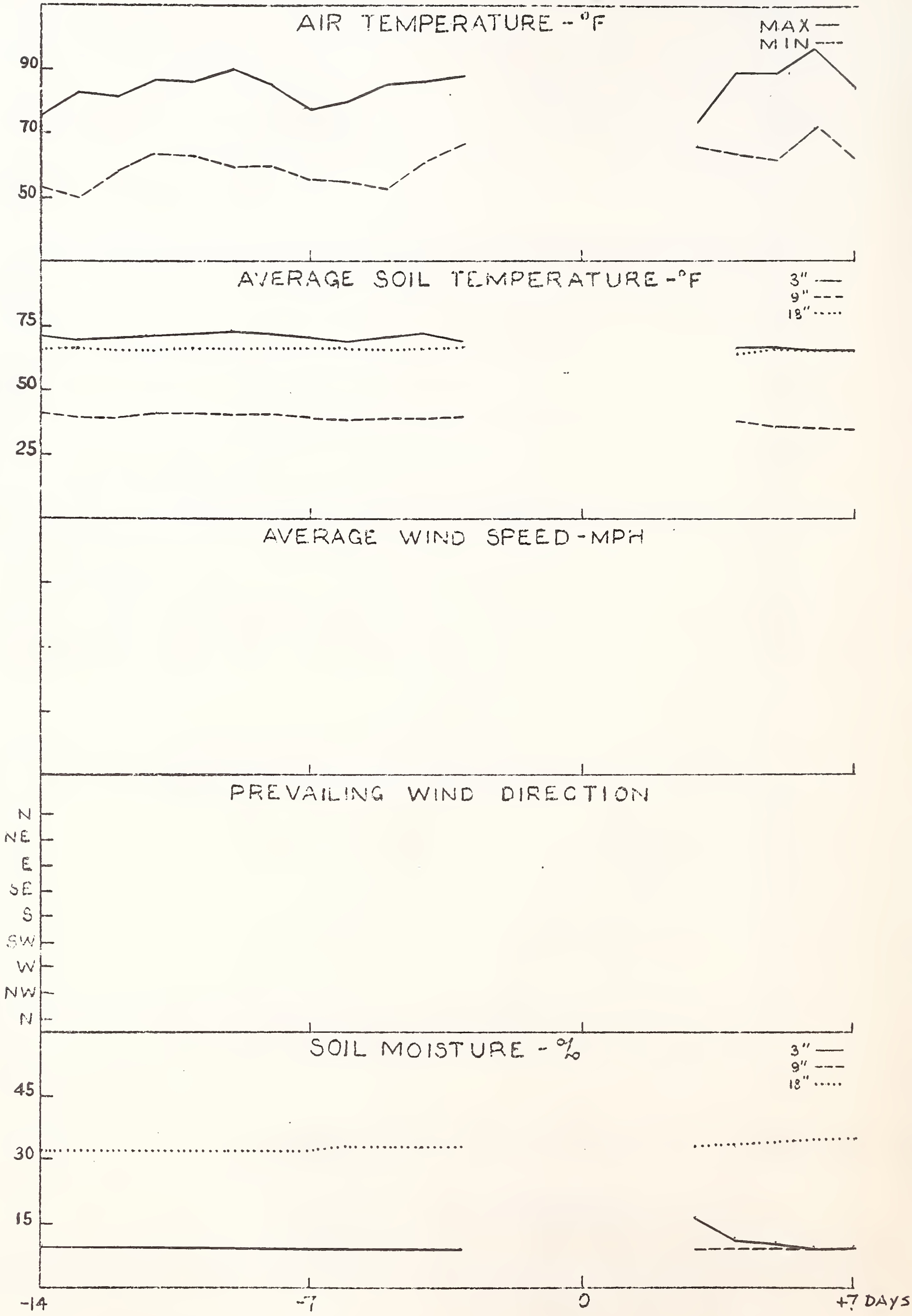
EAST FORK DUCK CREEK EVENT OF 7/5/65



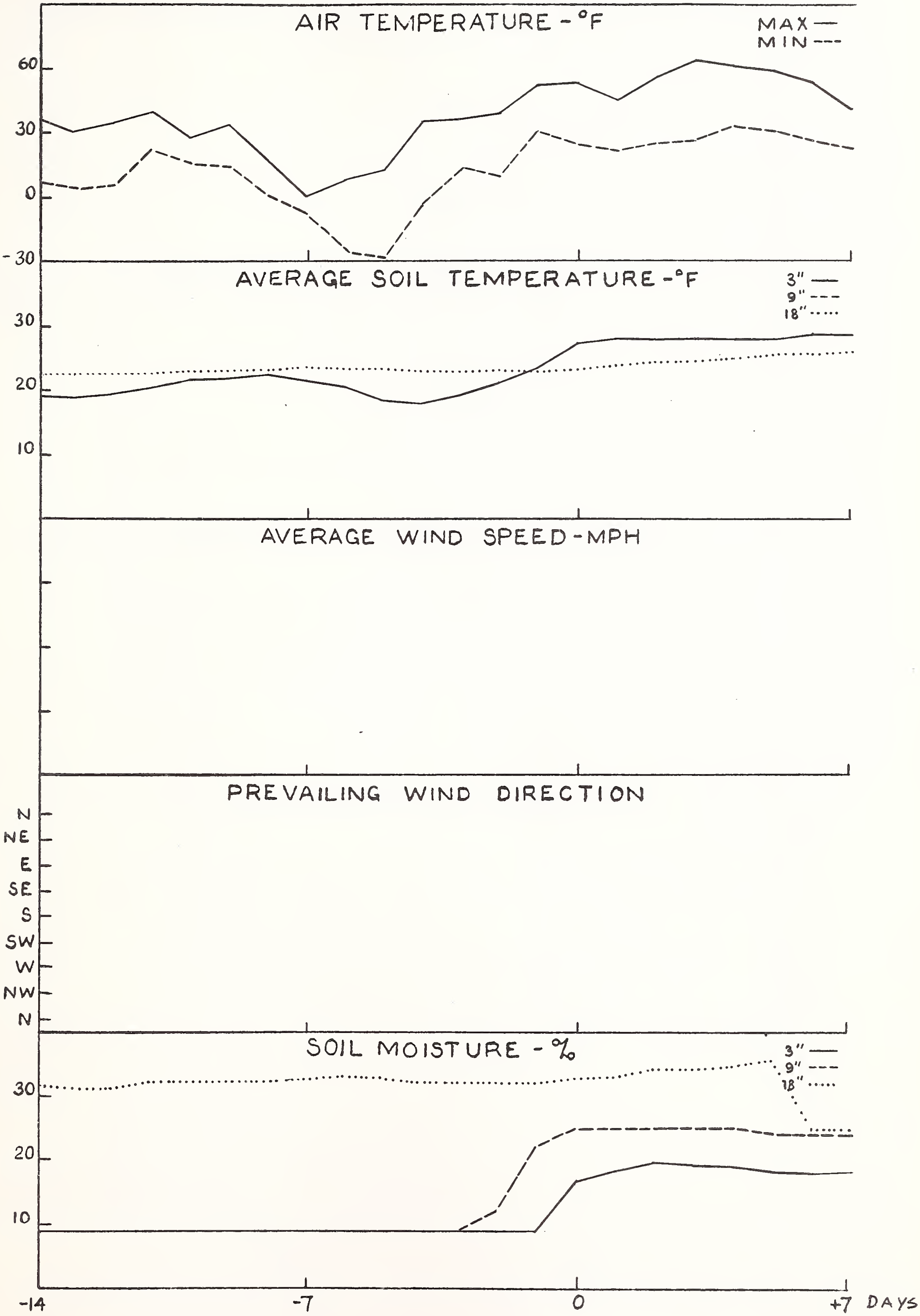
EAST FORK DUCK CREEK EVENT OF 7/12/65



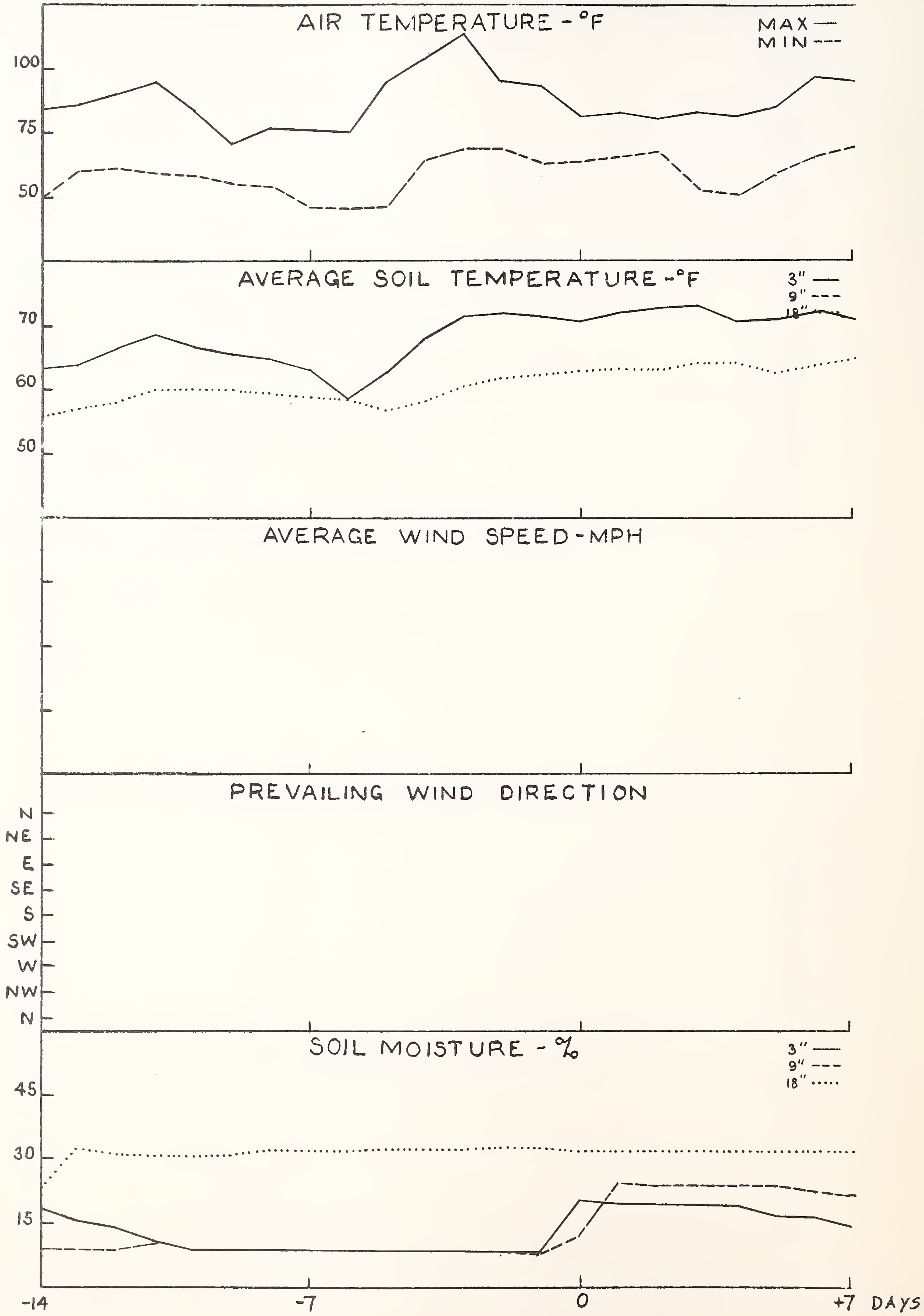
EAST FORK DUCK CREEK EVENT OF 8/6/65



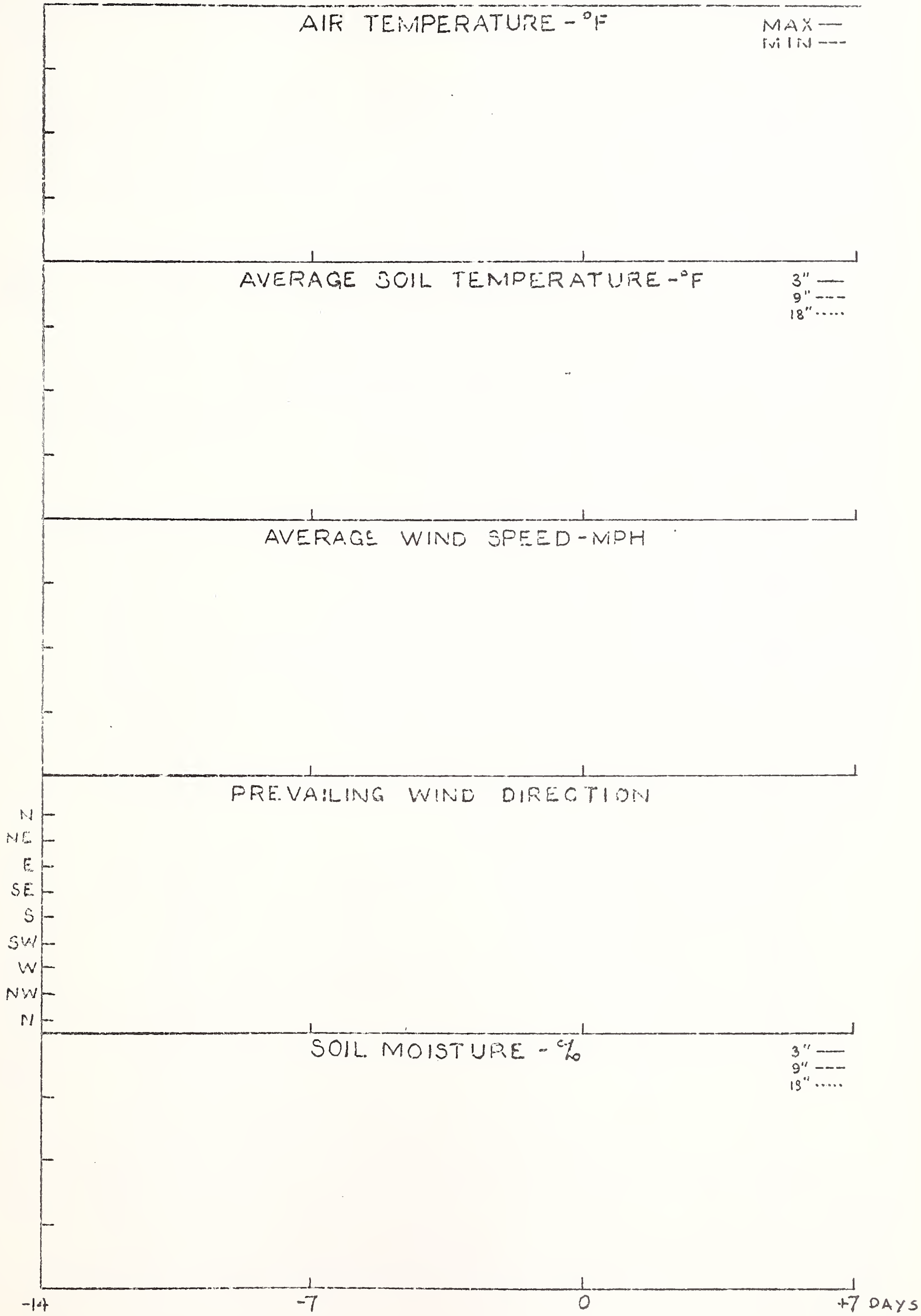
EAST FORK DUCK CREEK EVENT OF 3/10/66



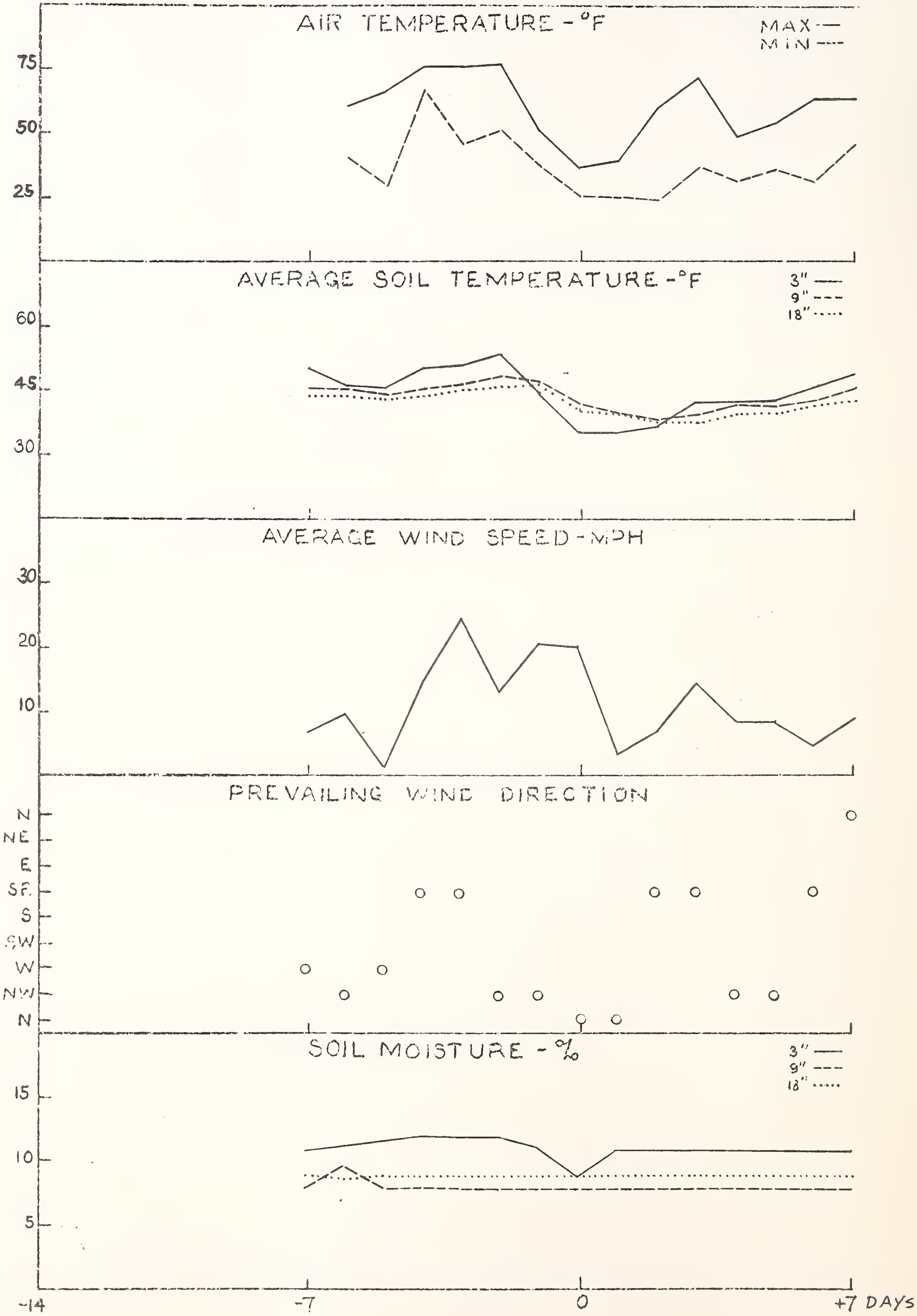
EAST FORK DUCK CREEK EVENT OF 7/1/66



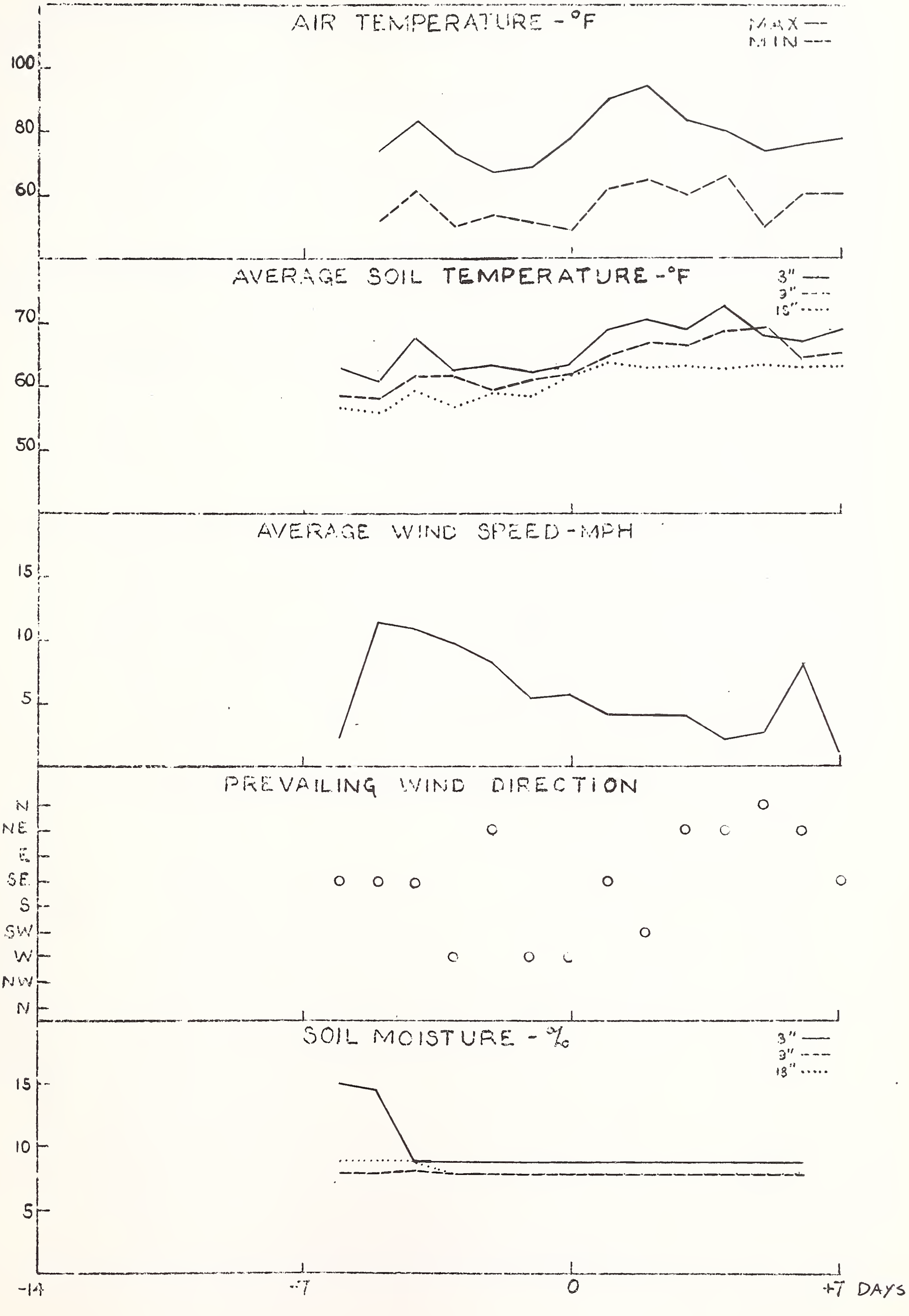
EAST FORK DUCK CREEK EVENT OF 3/17/69



EAST FORK DUCK CREEK EVENT OF 4/26/69

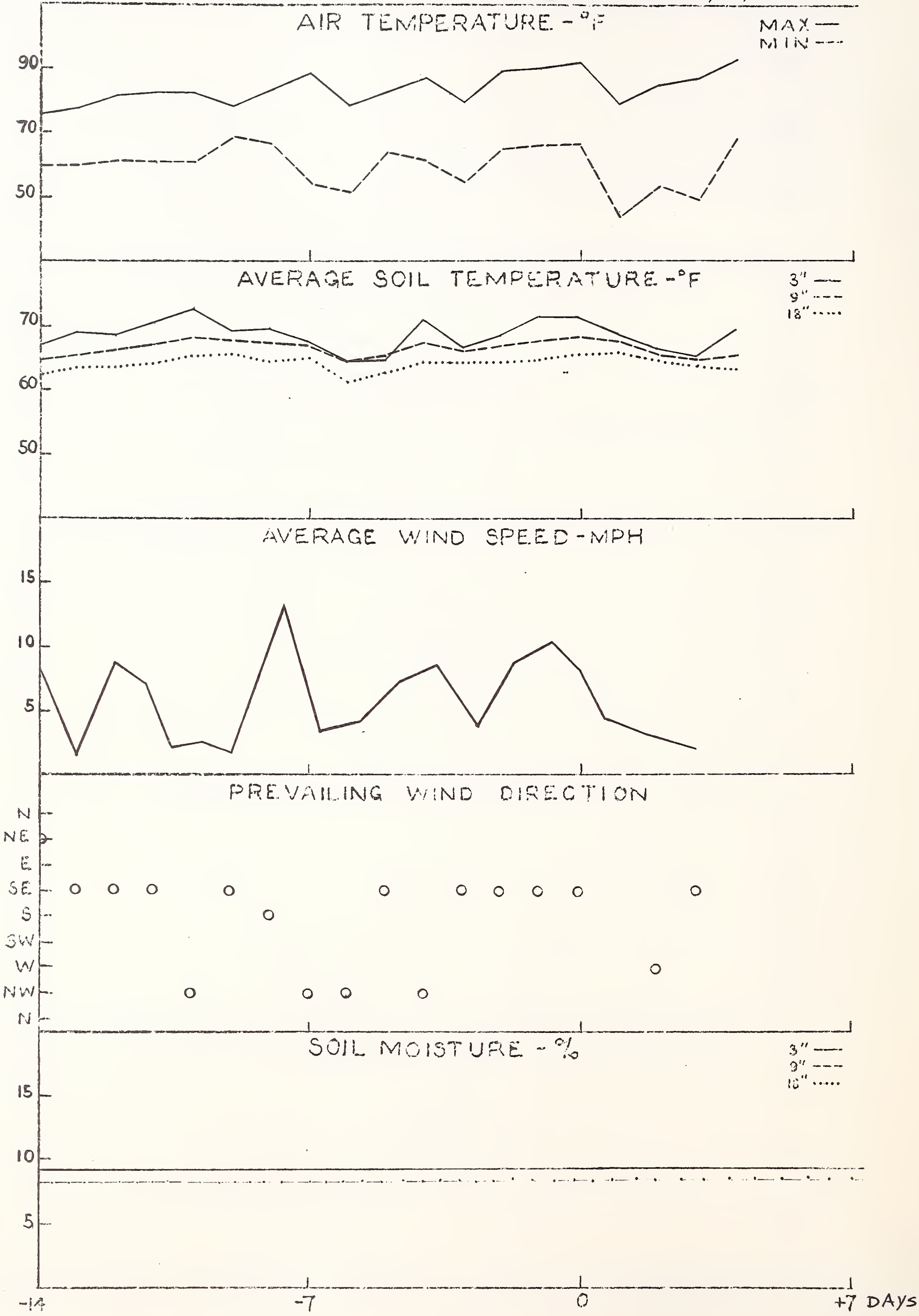


EAST FORK DUCK CREEK EVENT OF 7/7/69

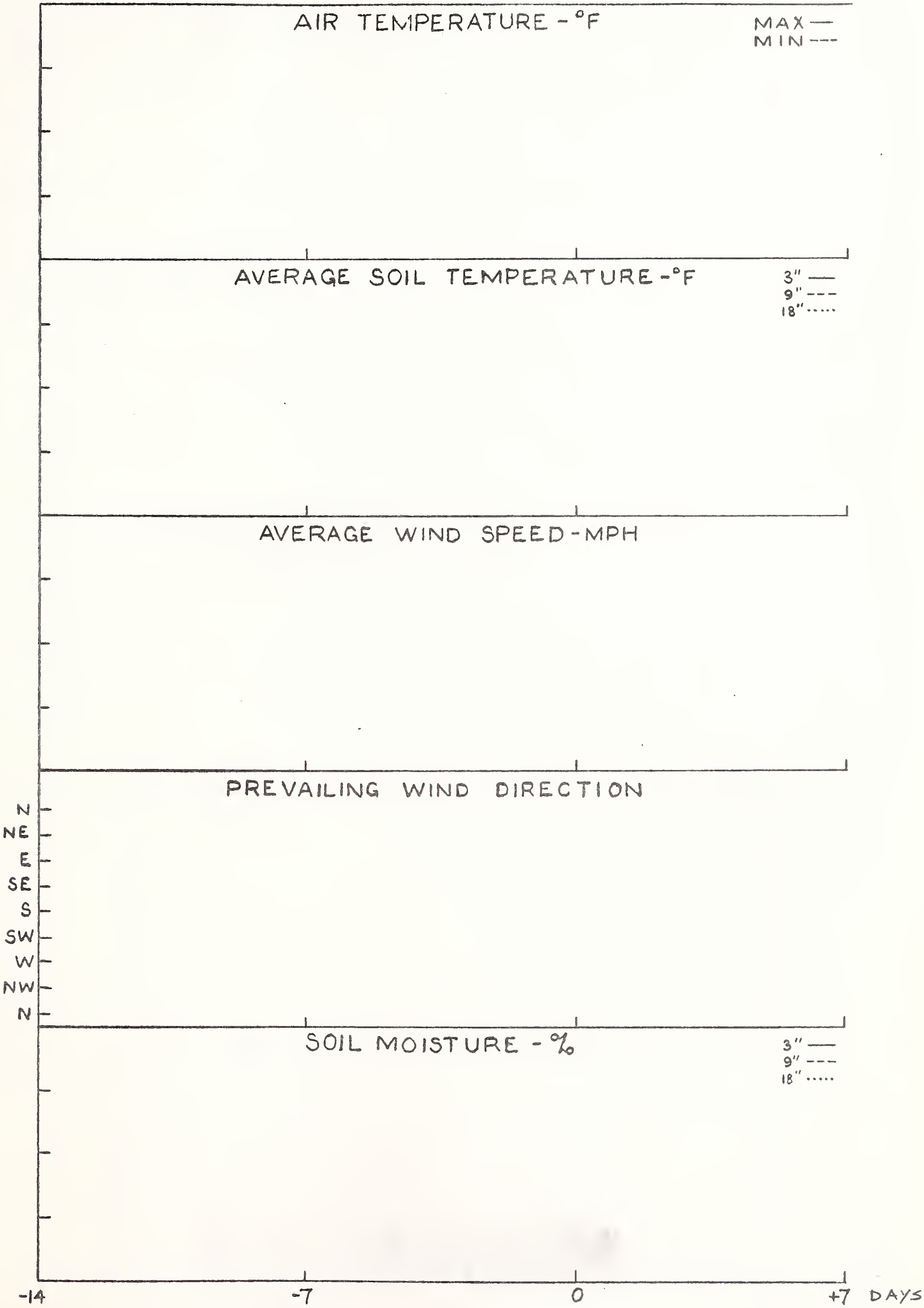


EAST FORK DUCK CREEK

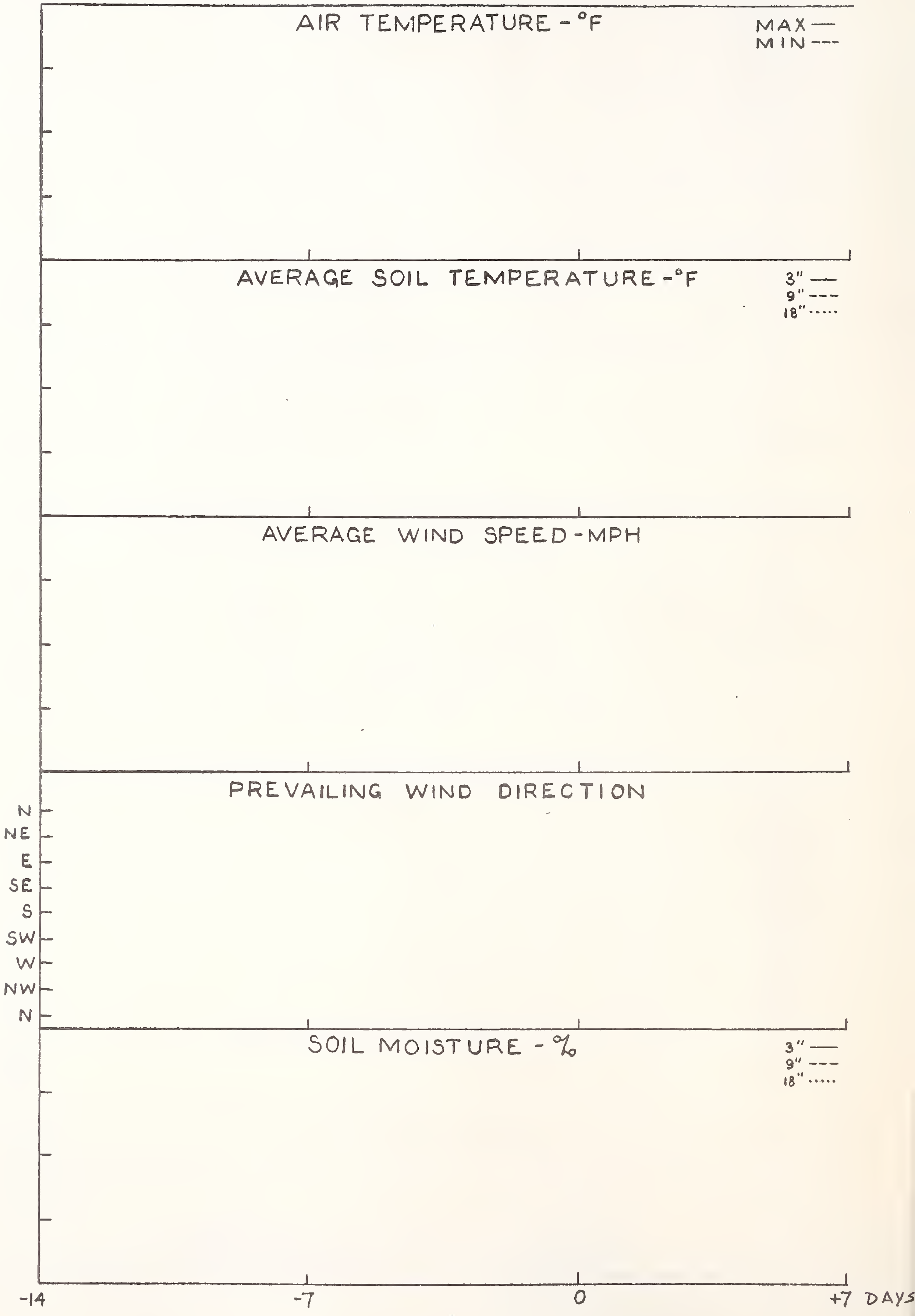
EVENT OF 7/27/69



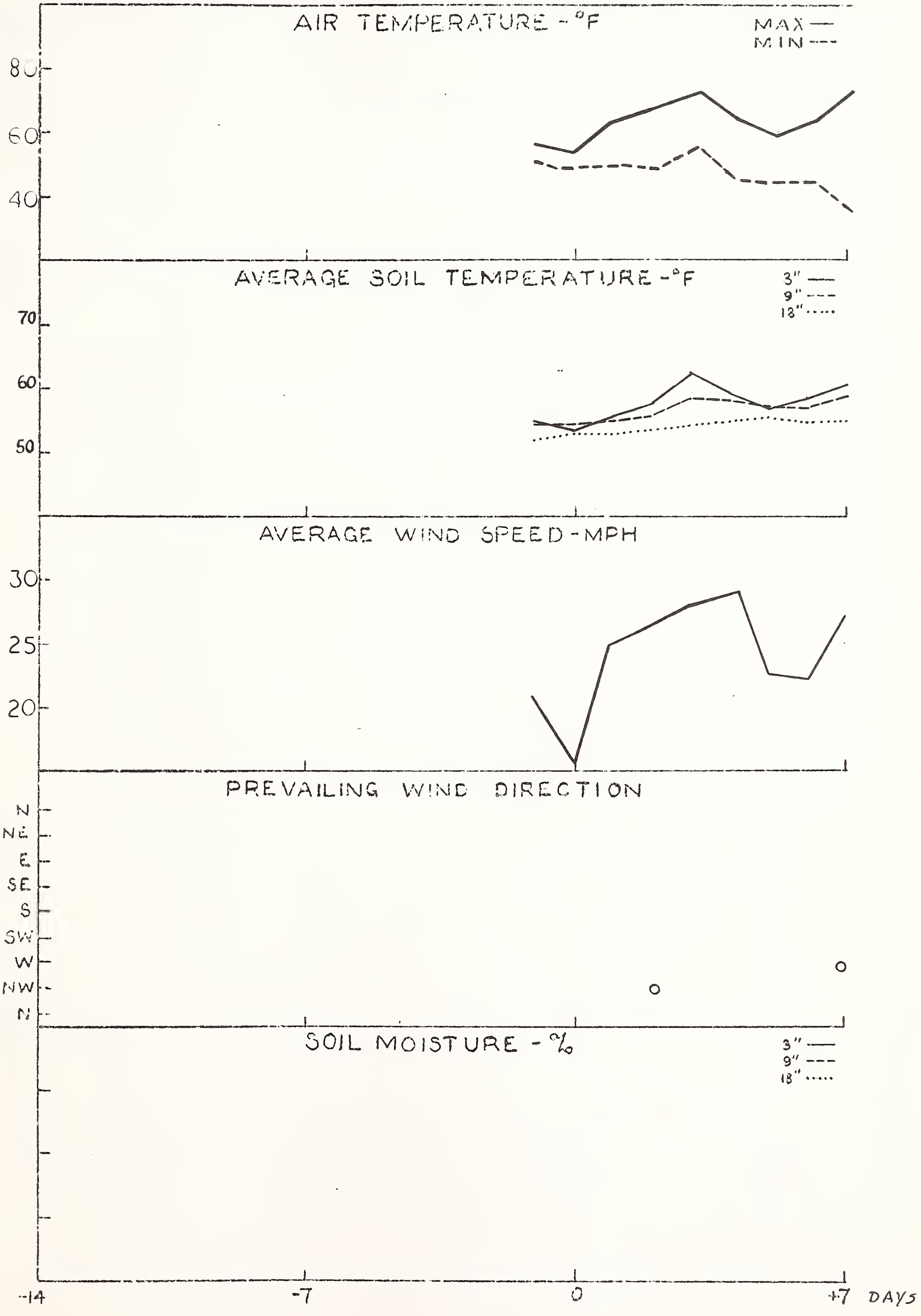
HUMP CREEK EVENT OF 6/14/67



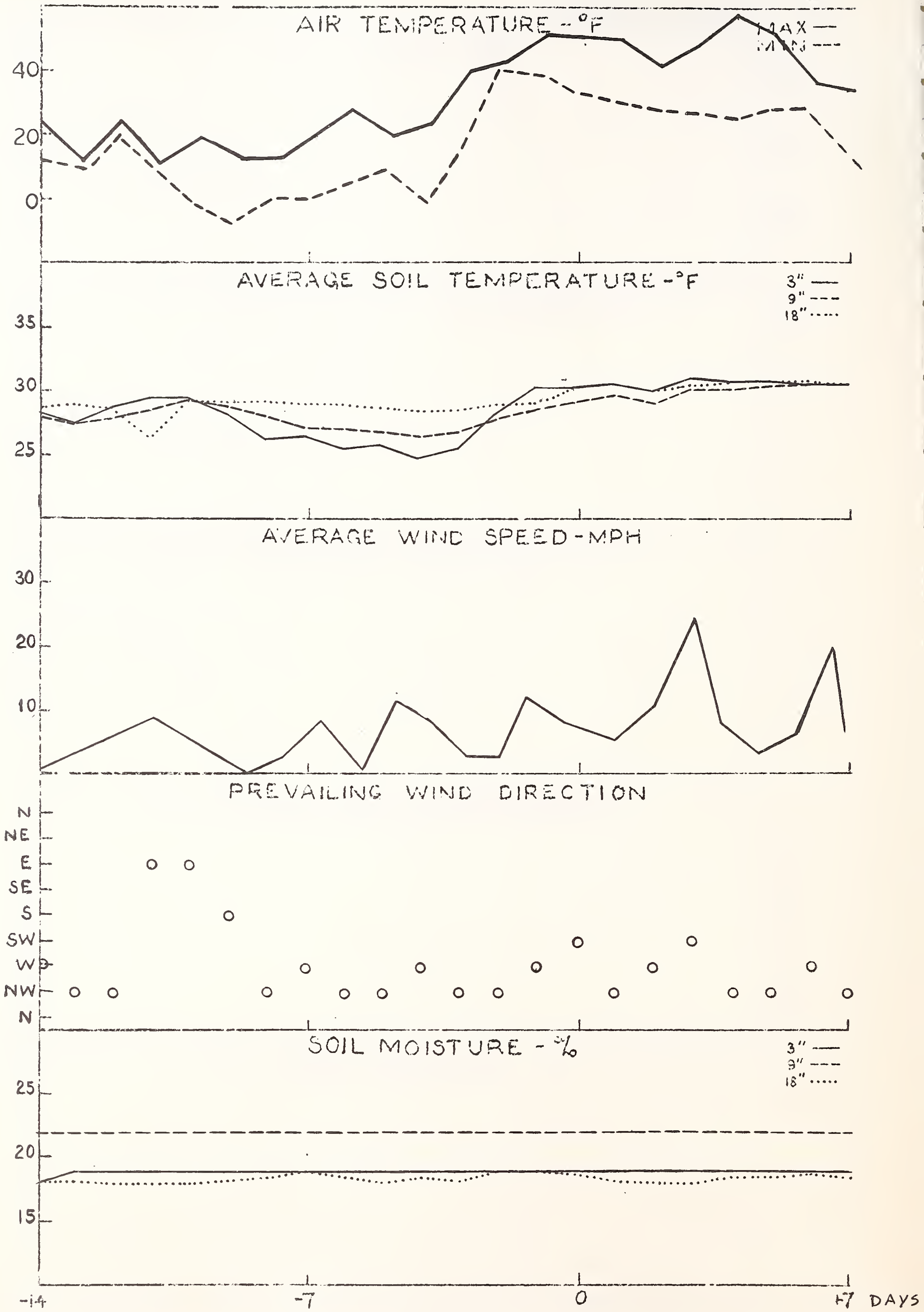
HUMP CREEK EVENT OF 6/27/67



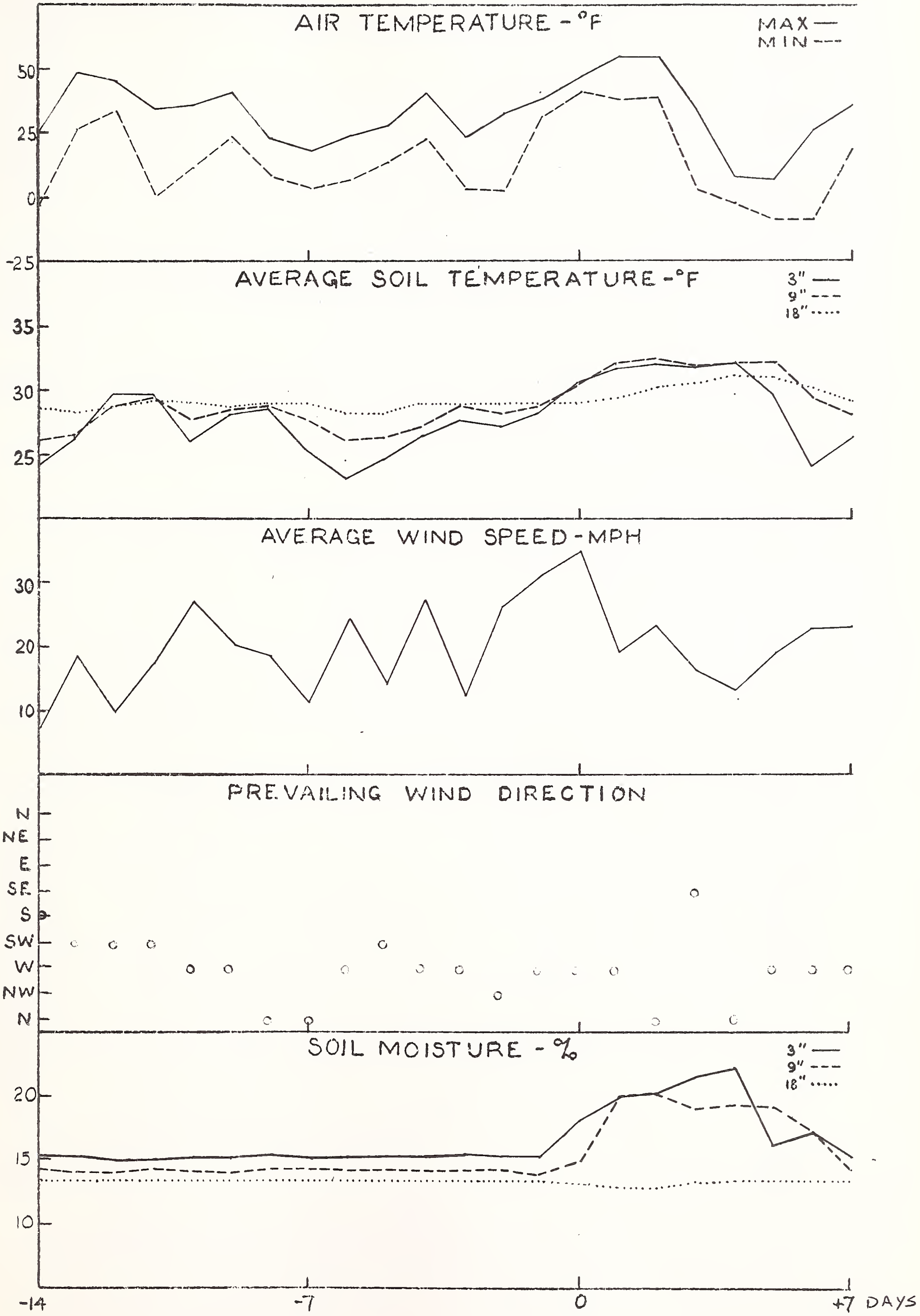
HUMP CREEK EVENT OF 6/9/68



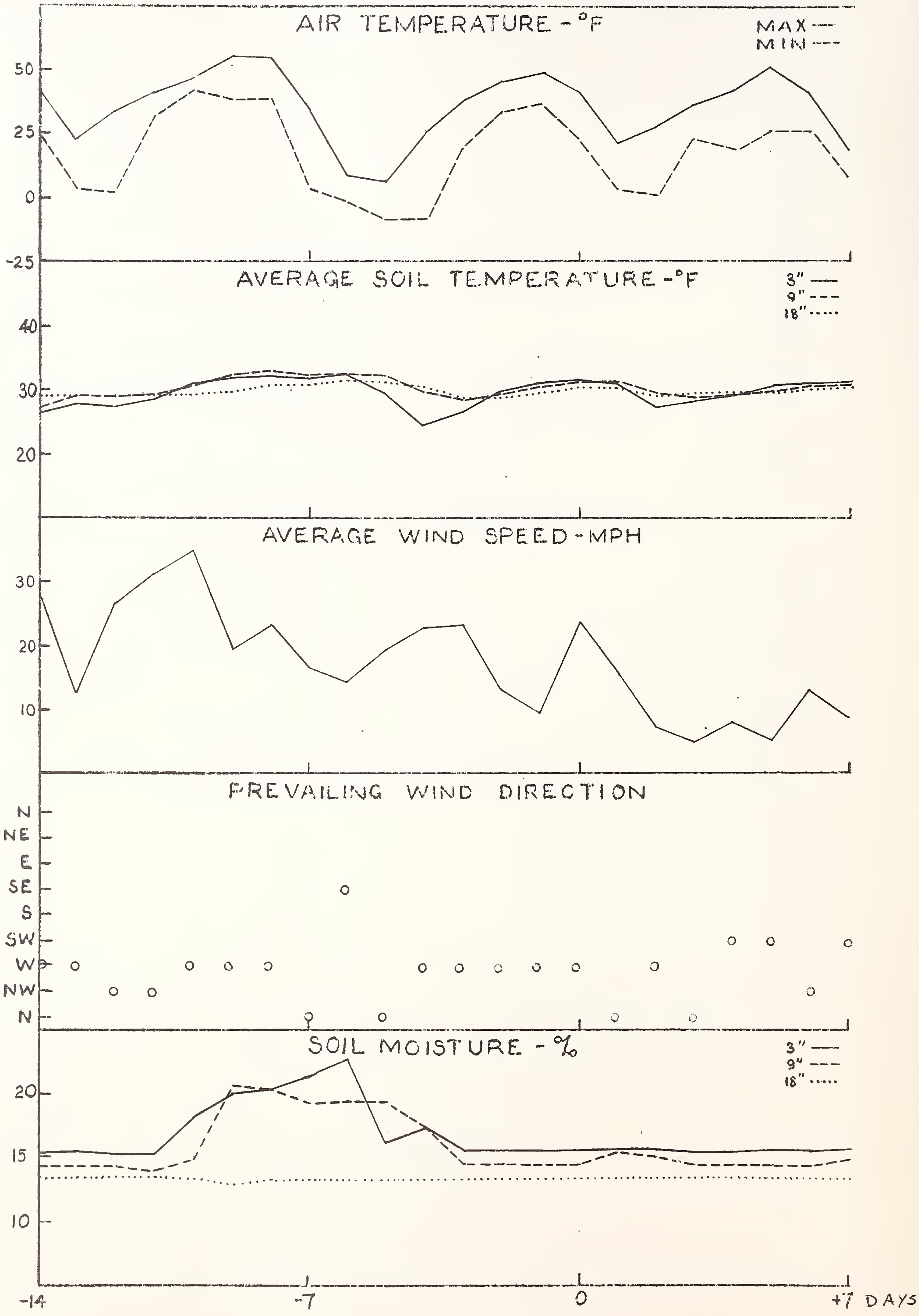
HUMP CREEK EVENT OF 3/17/69



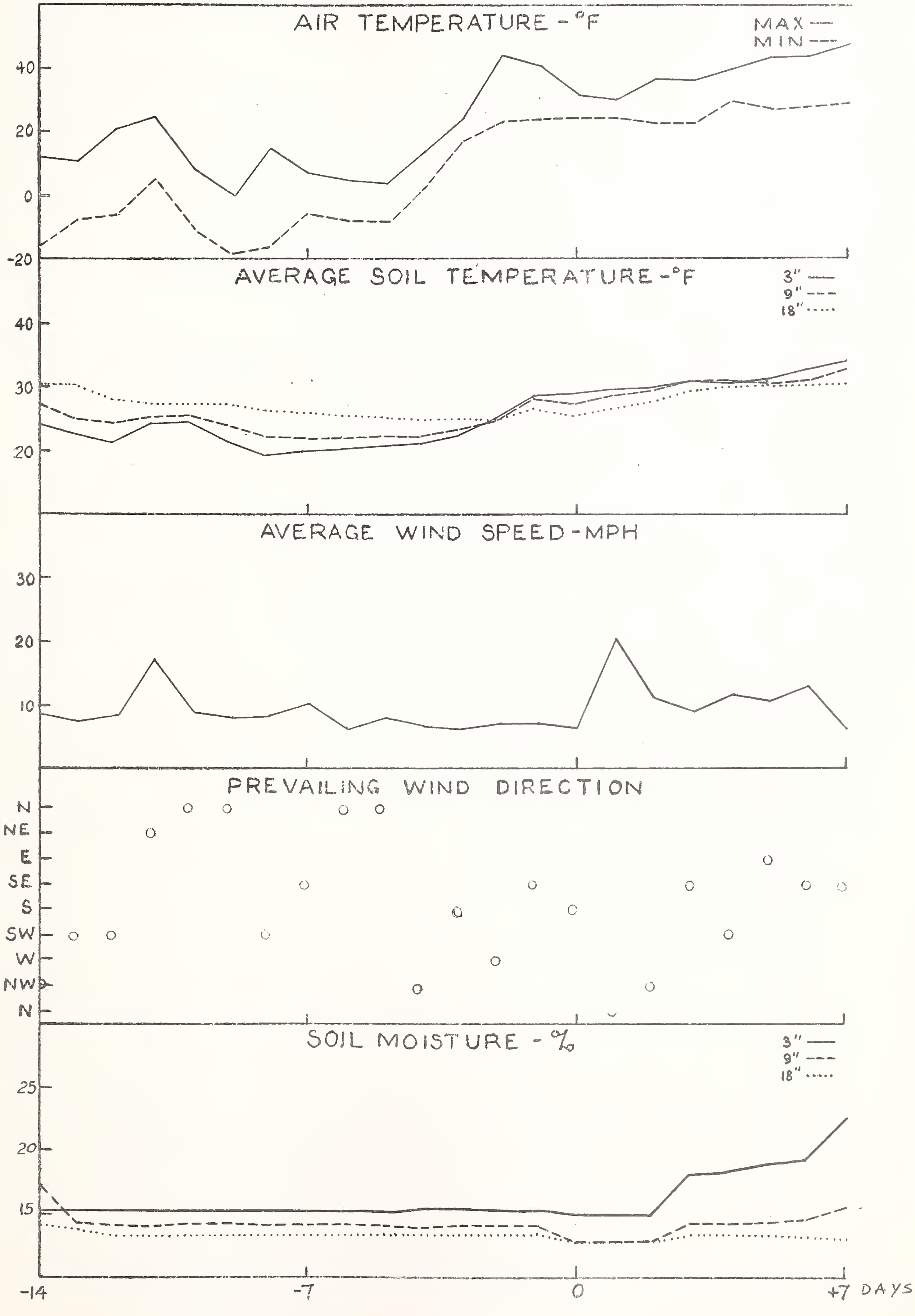
LONE MAN COULEE EVENT OF 2/17/65



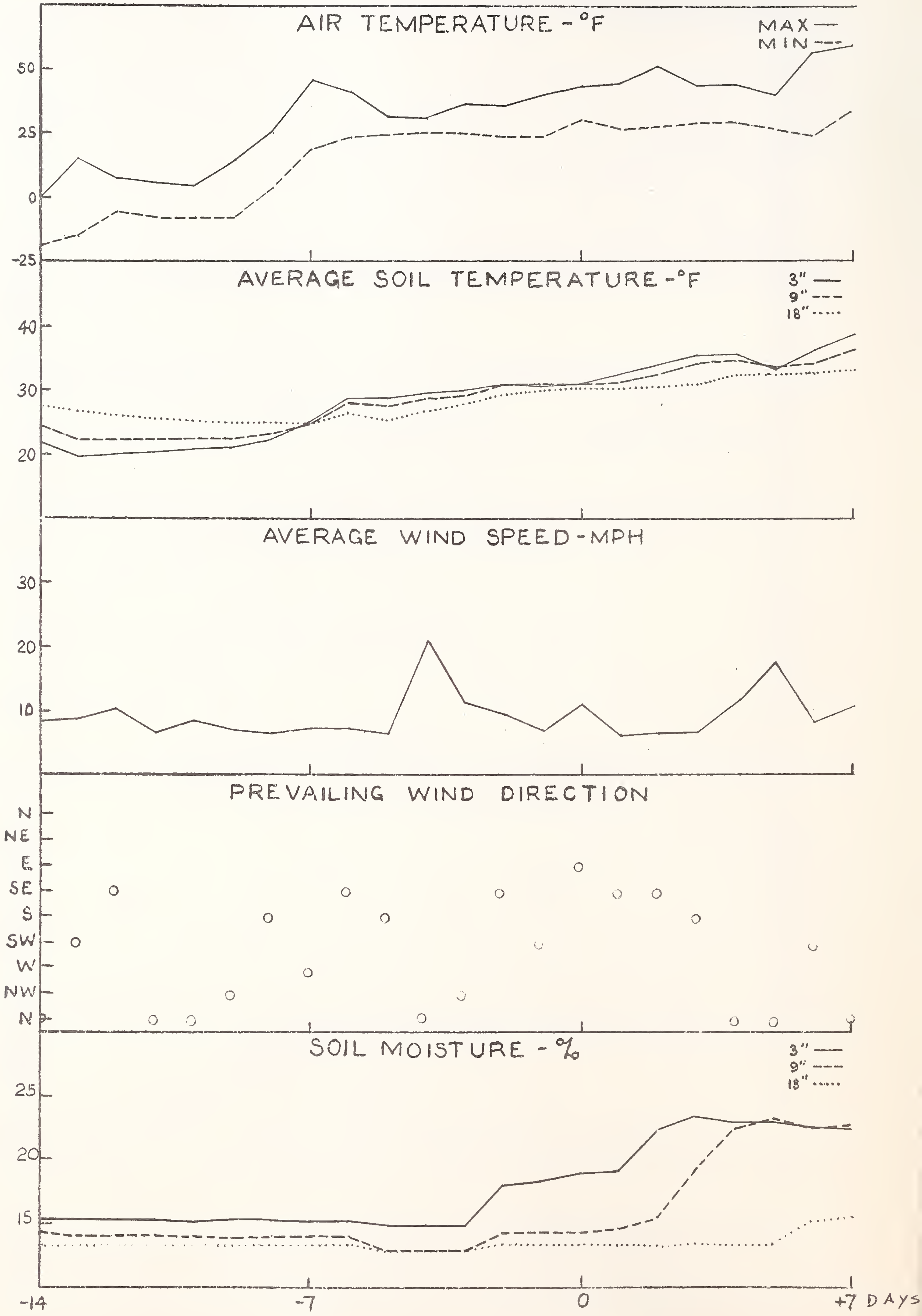
LONE MAN COULEE EVENT OF 2/27/65



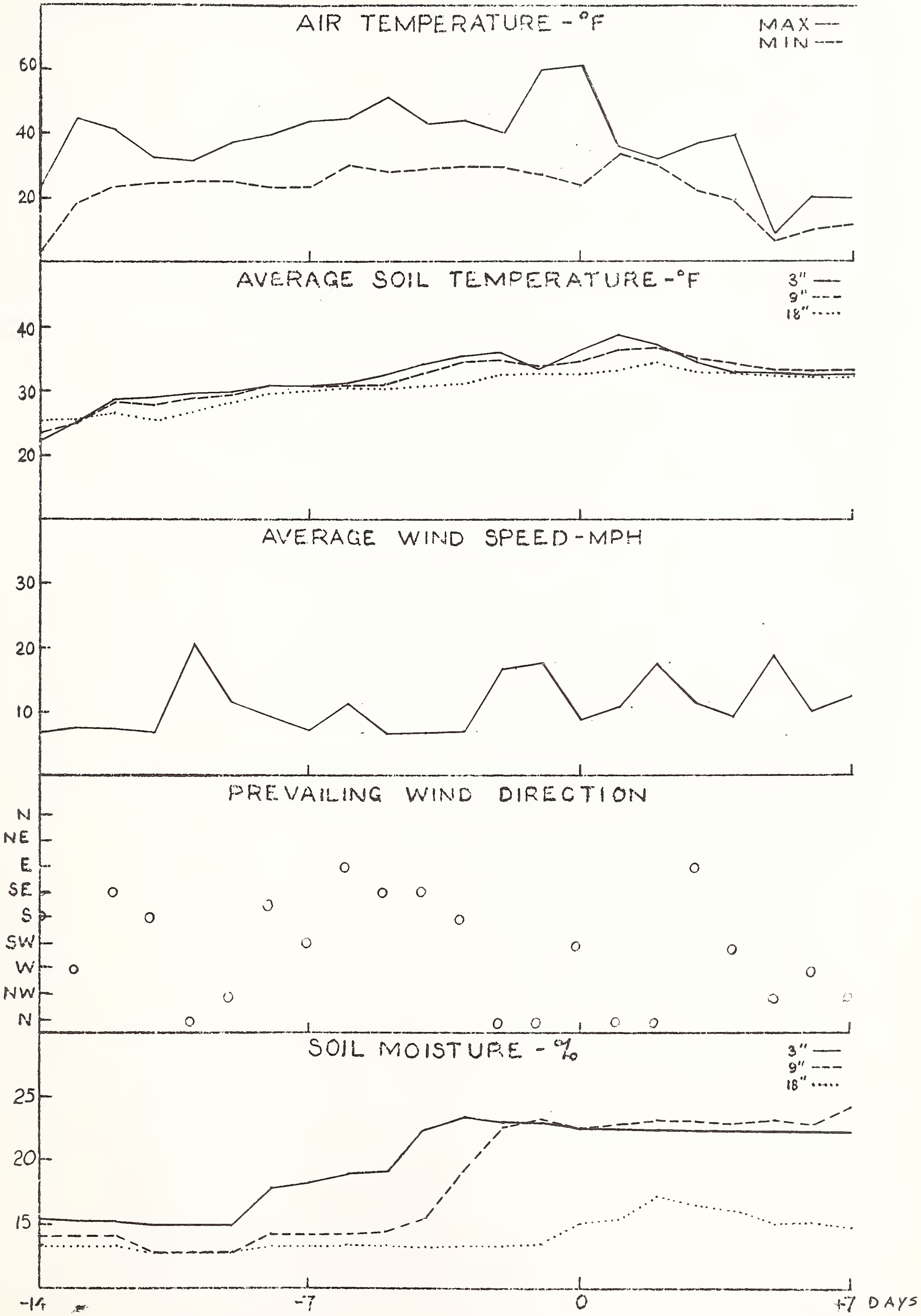
LONE MAN COULEE EVENT OF 4/1/65



LONE MAN COULEE EVENT OF 4/6/65



LONE MAN COULEE EVENT OF 4/12/65



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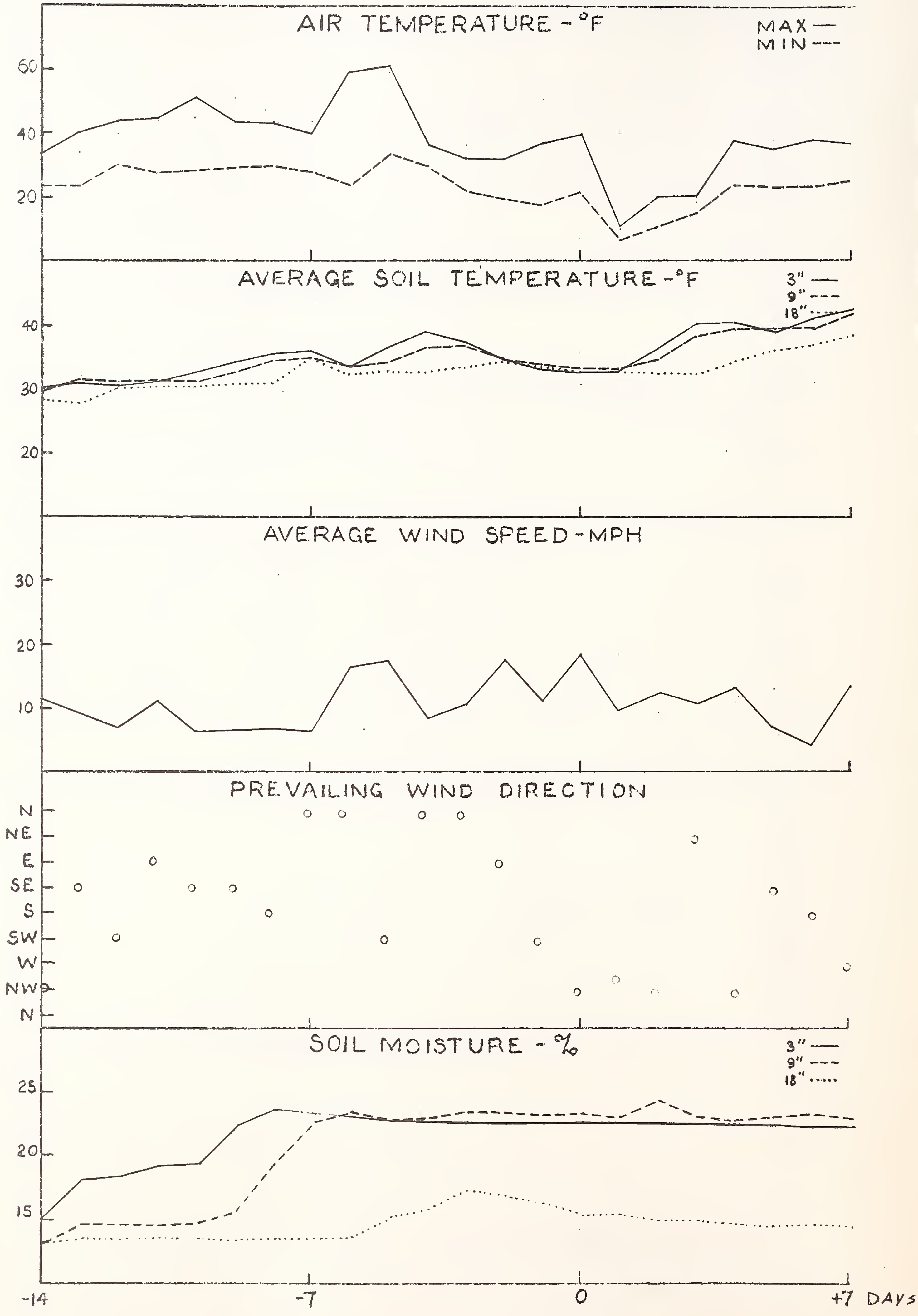

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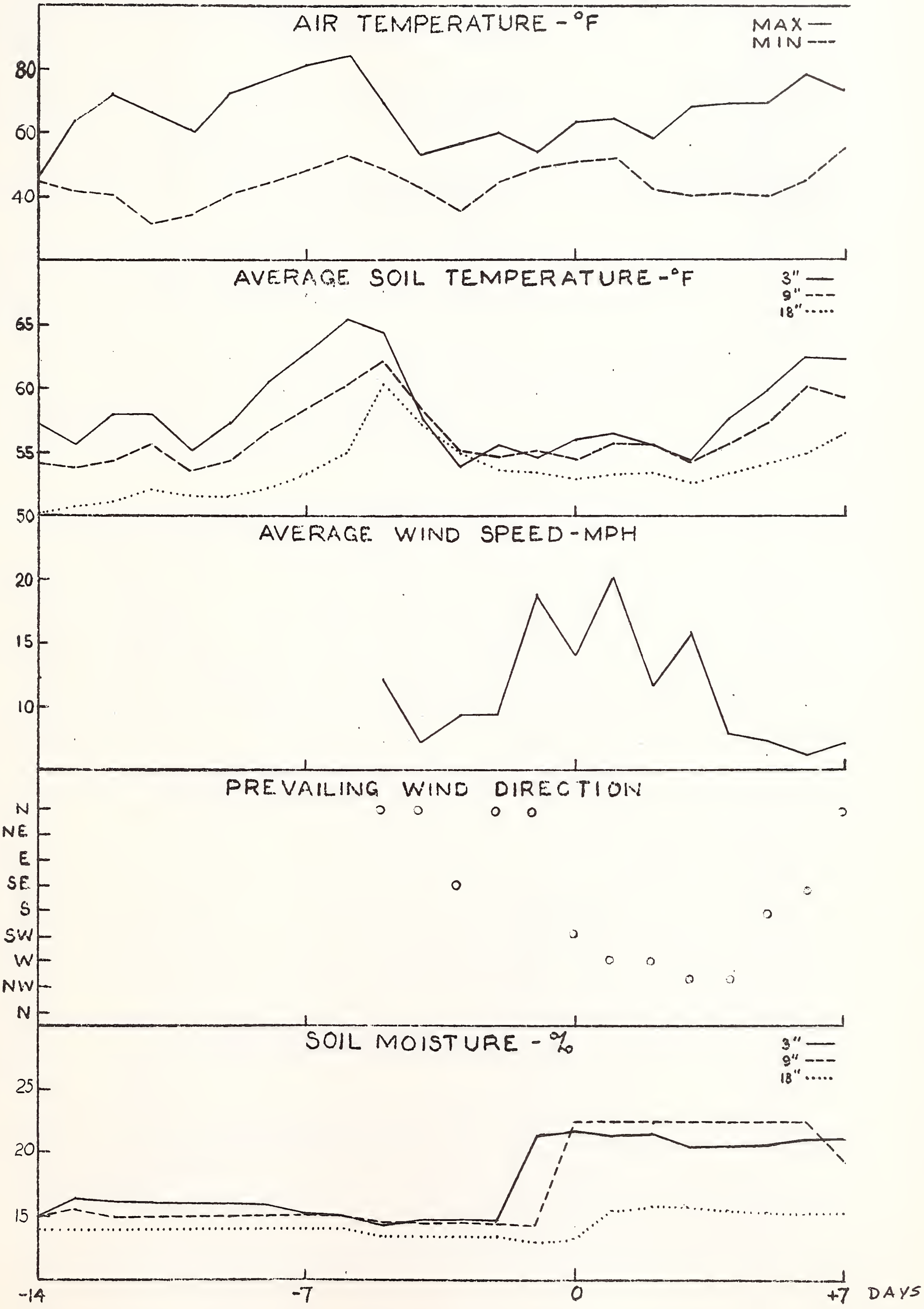

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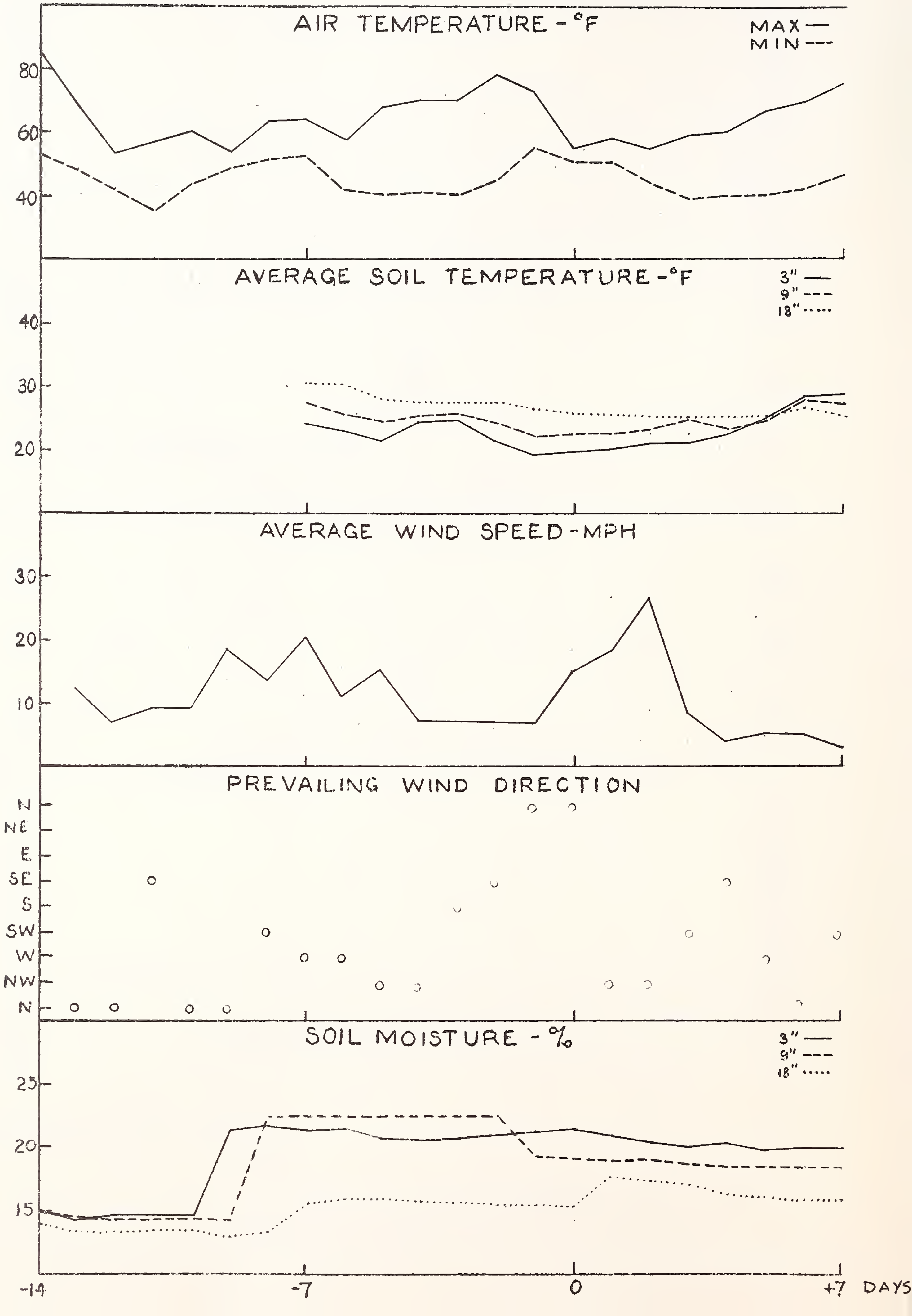
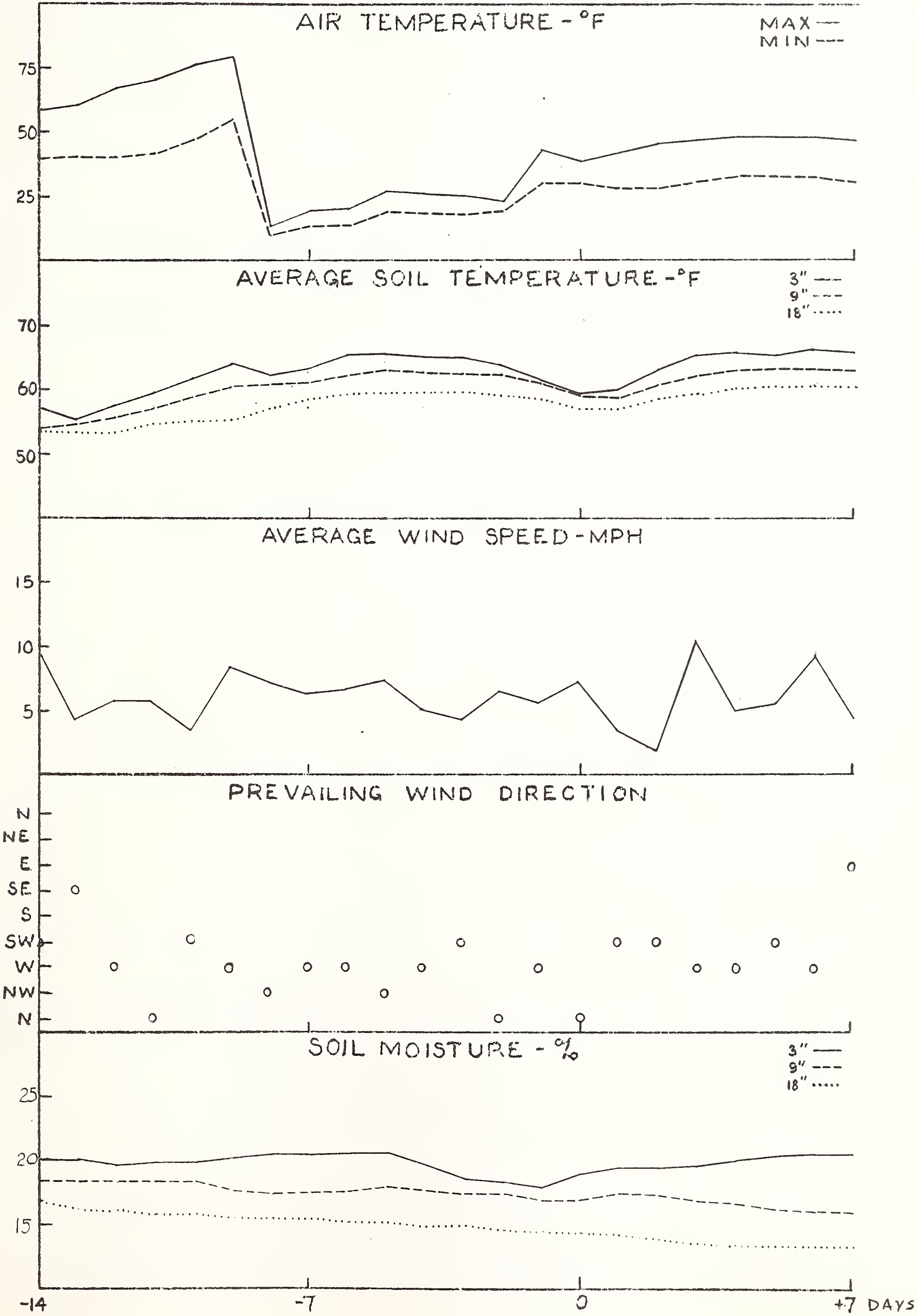
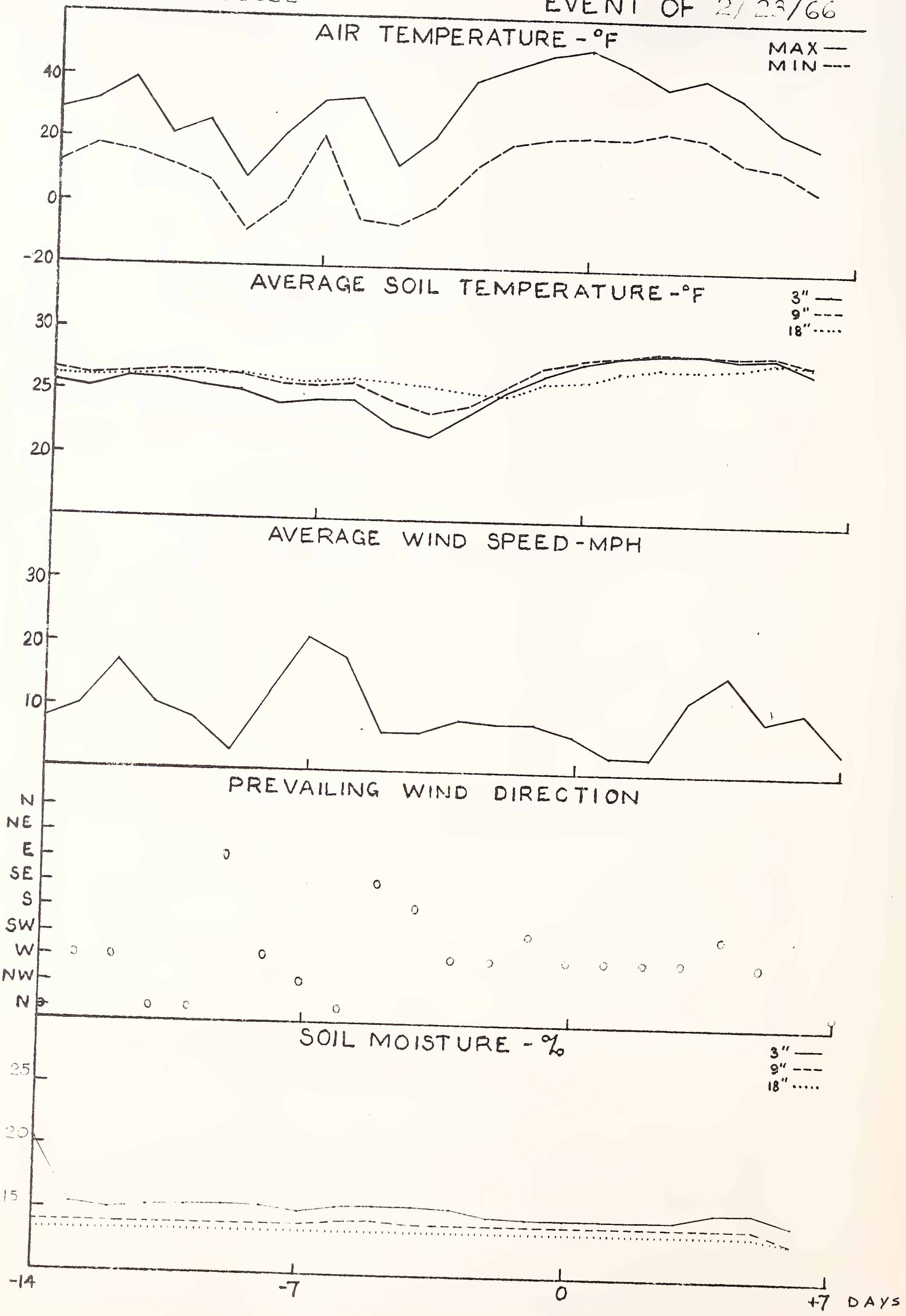


LONE MAN COULEE. EVENT OF 7/12/65

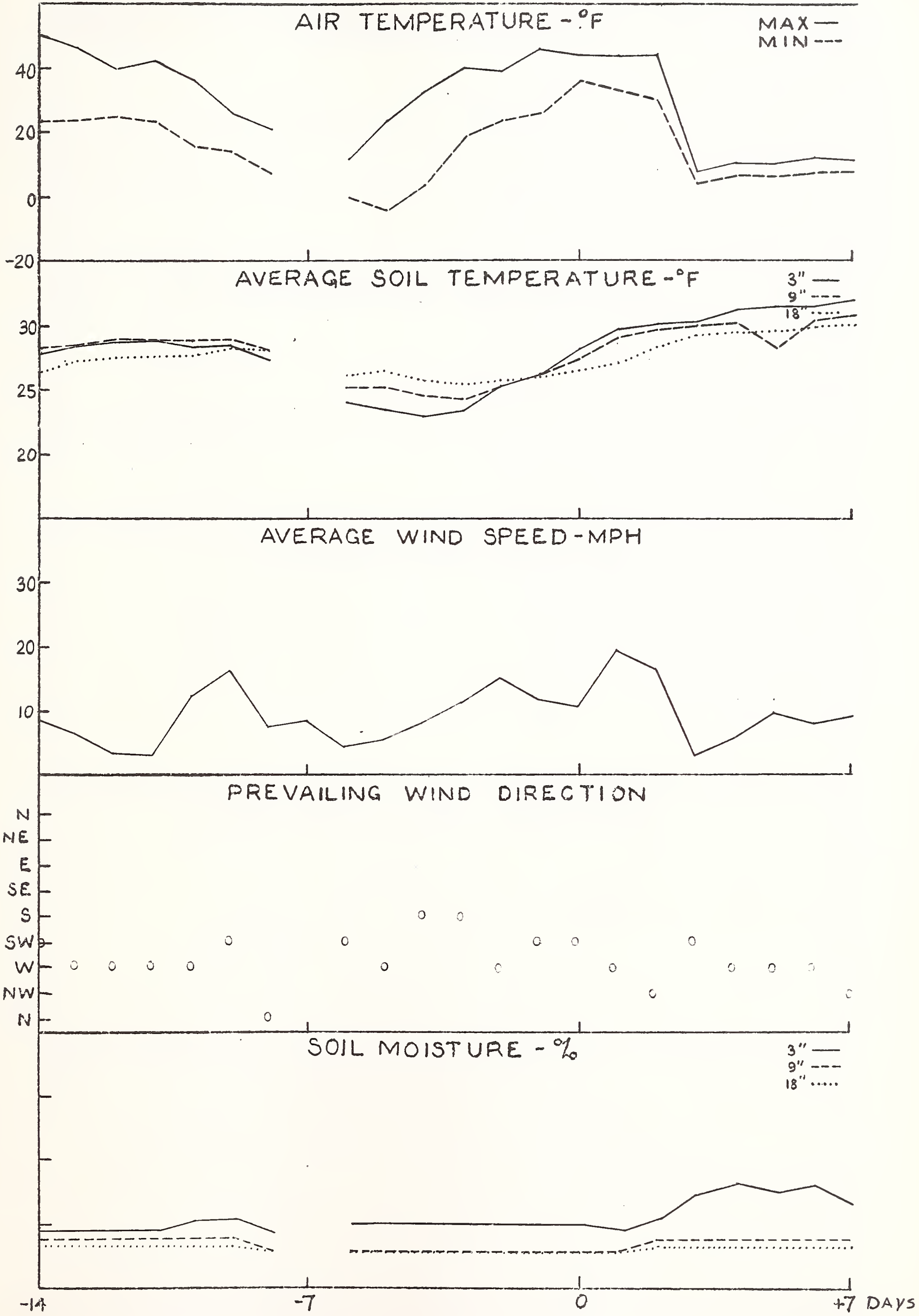


LONE MAN COULEE

EVENT OF 2/23/66



LONE MAN COULEE EVENT OF 3/9/66



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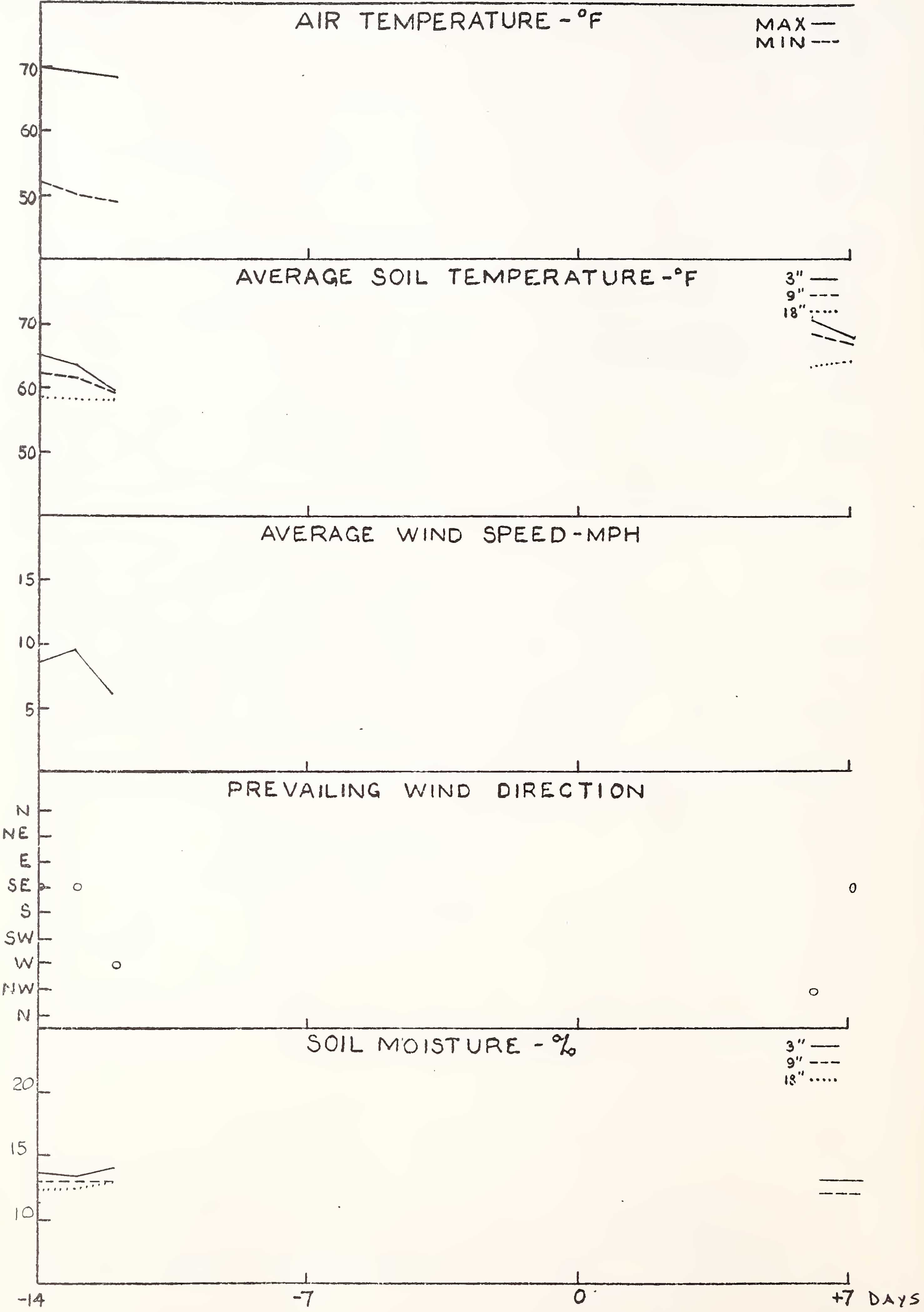

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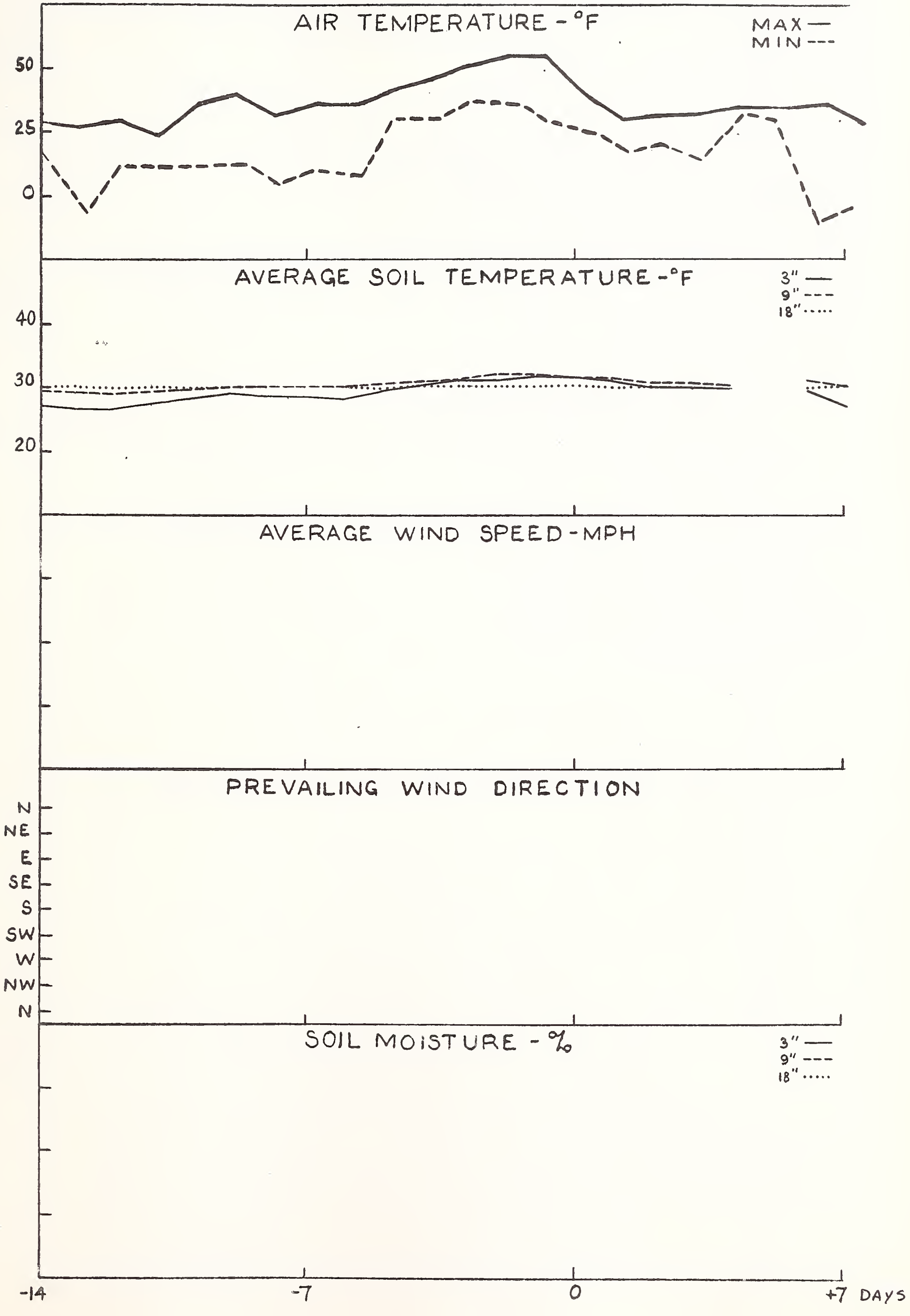

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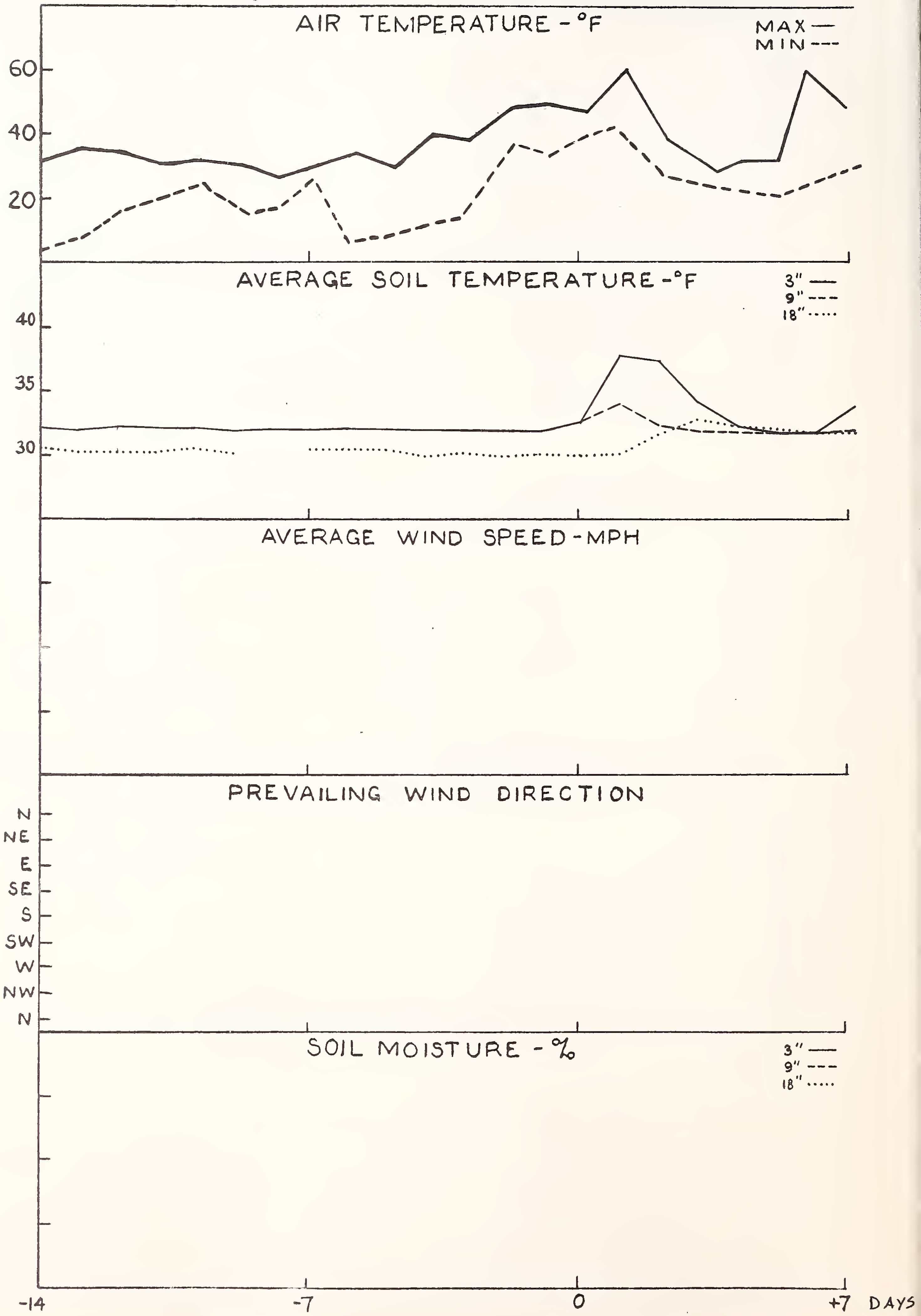

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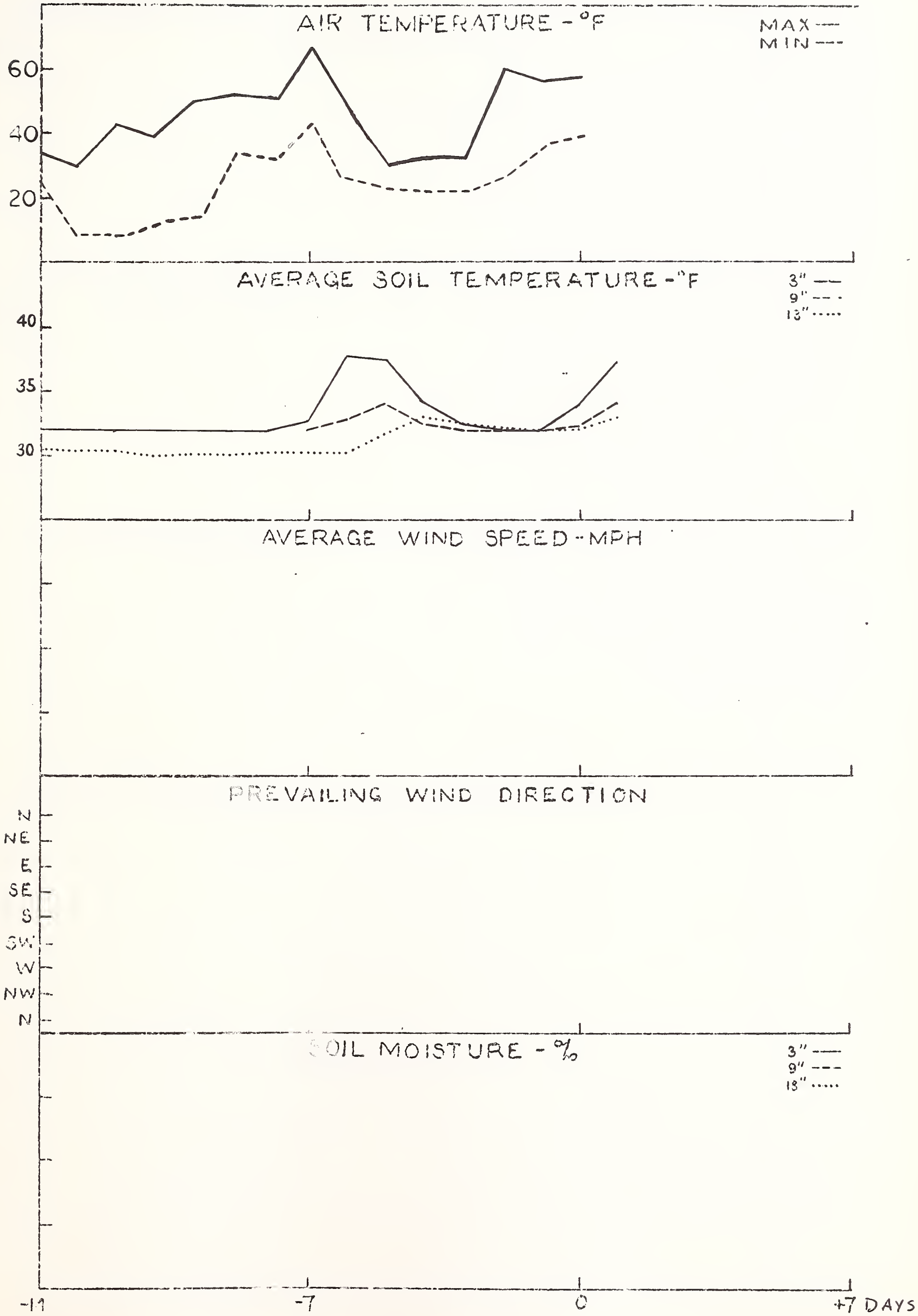
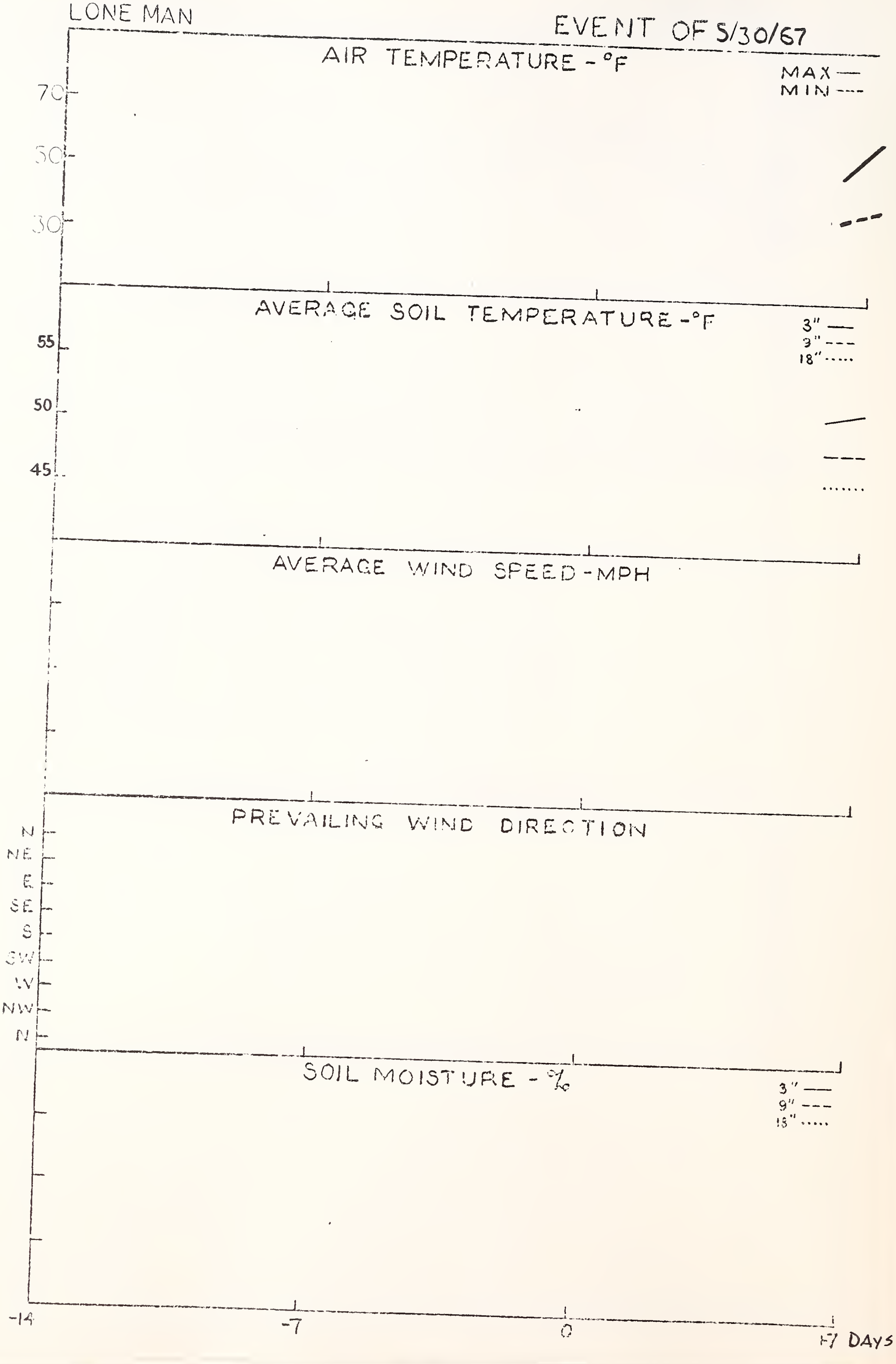


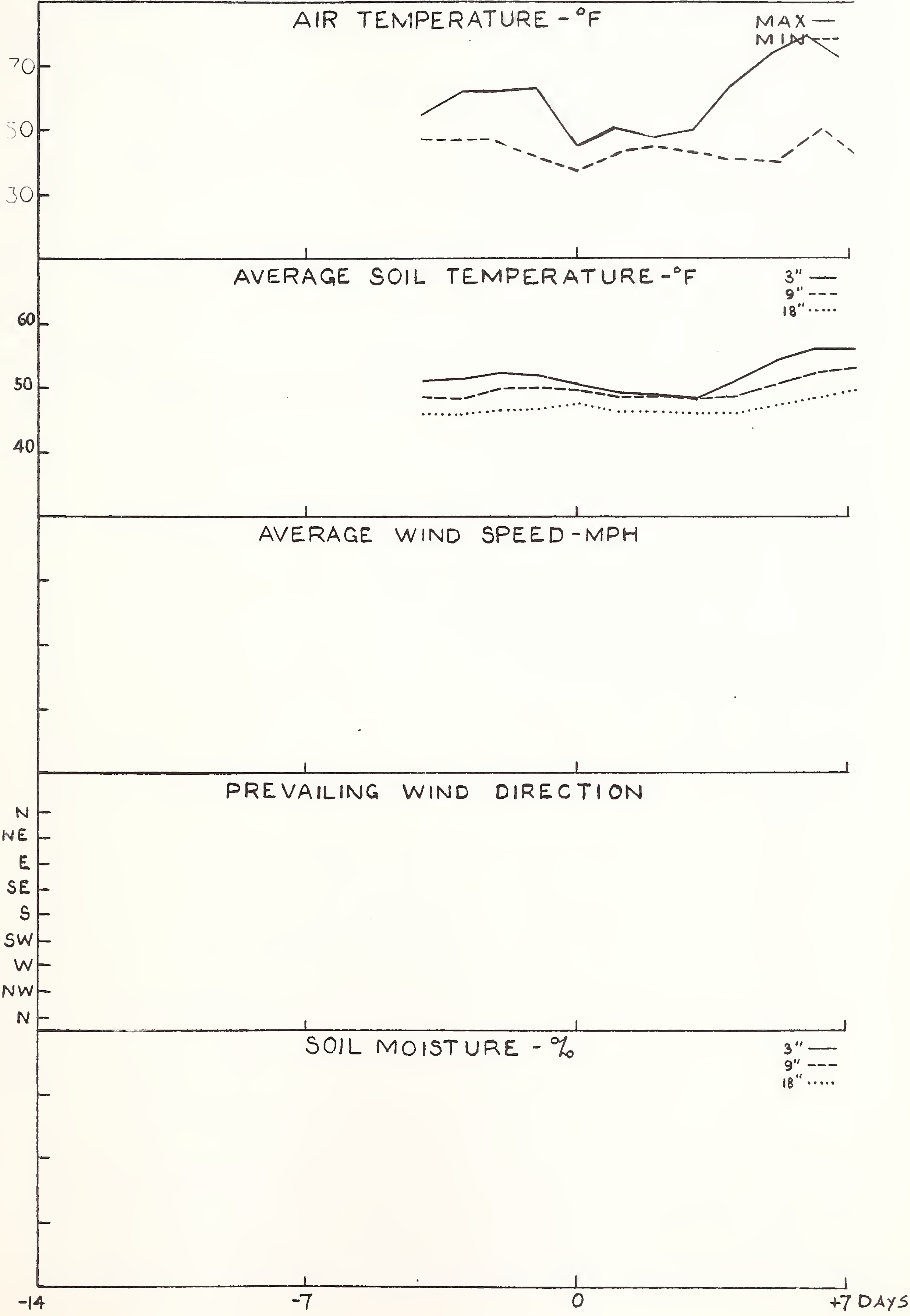
LONE MAN

EVENT OF 5/30/67

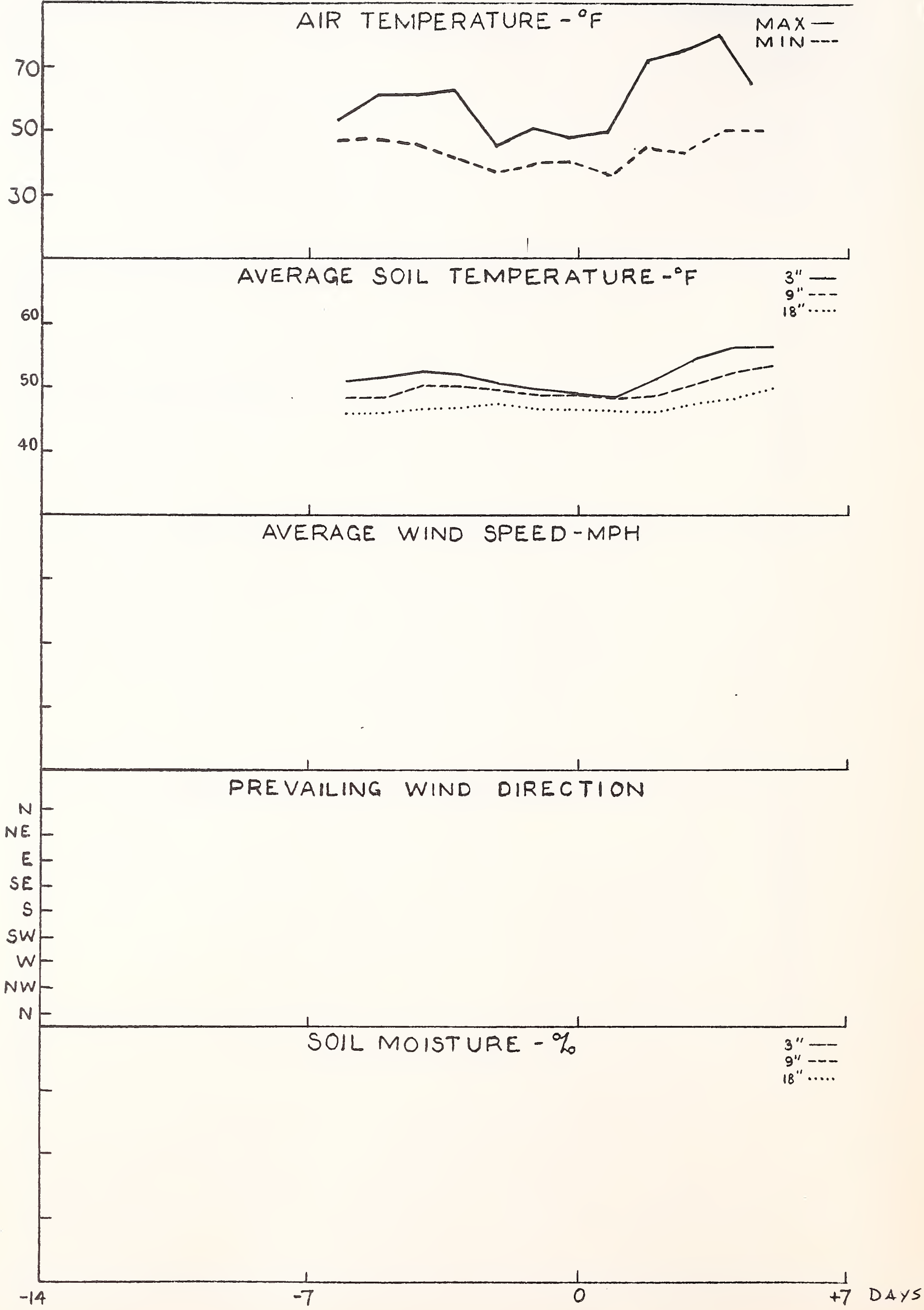


LONE MAN

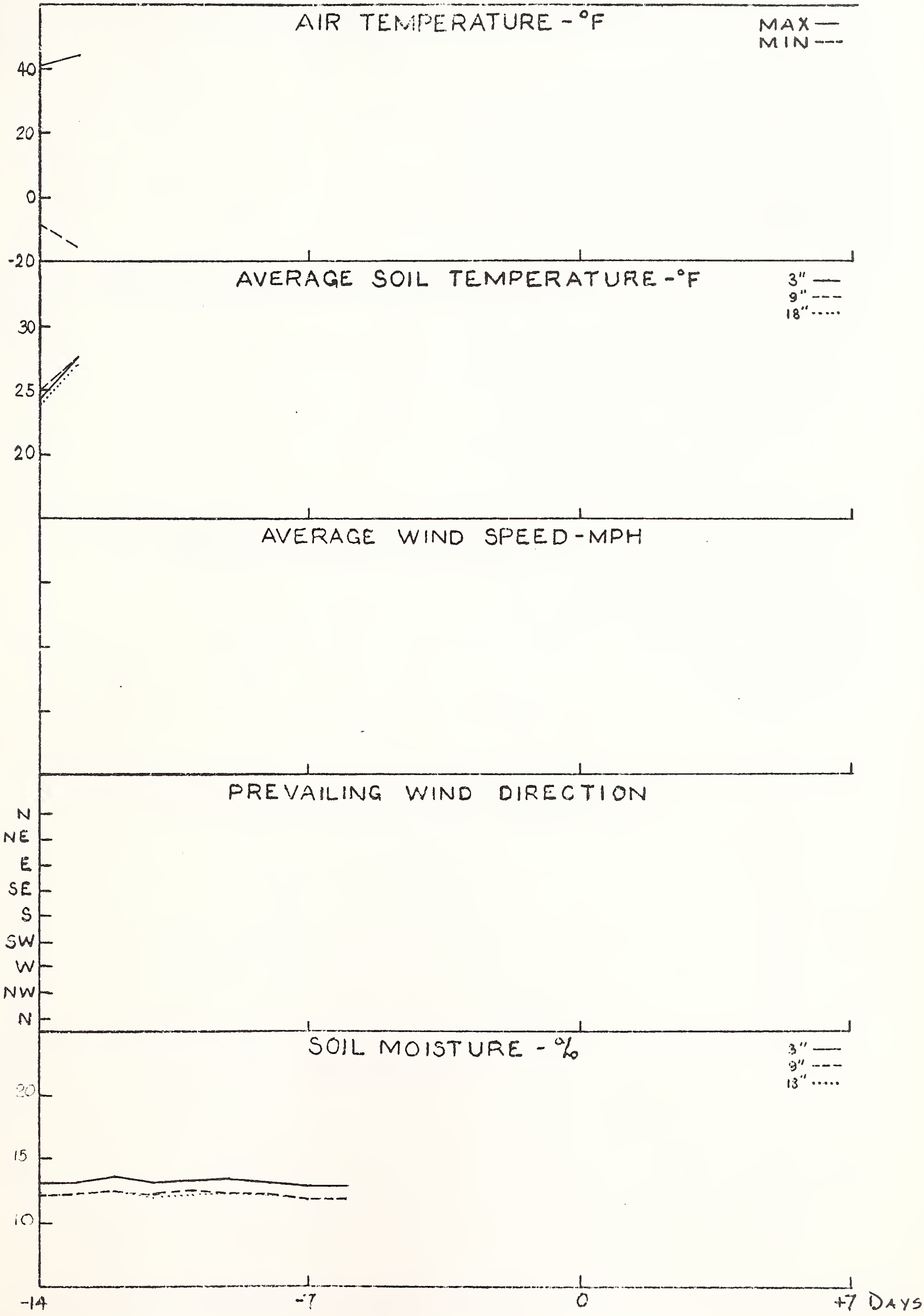
EVENT OF 6/10/67



LONE MAN EVENT OF 6/12/67

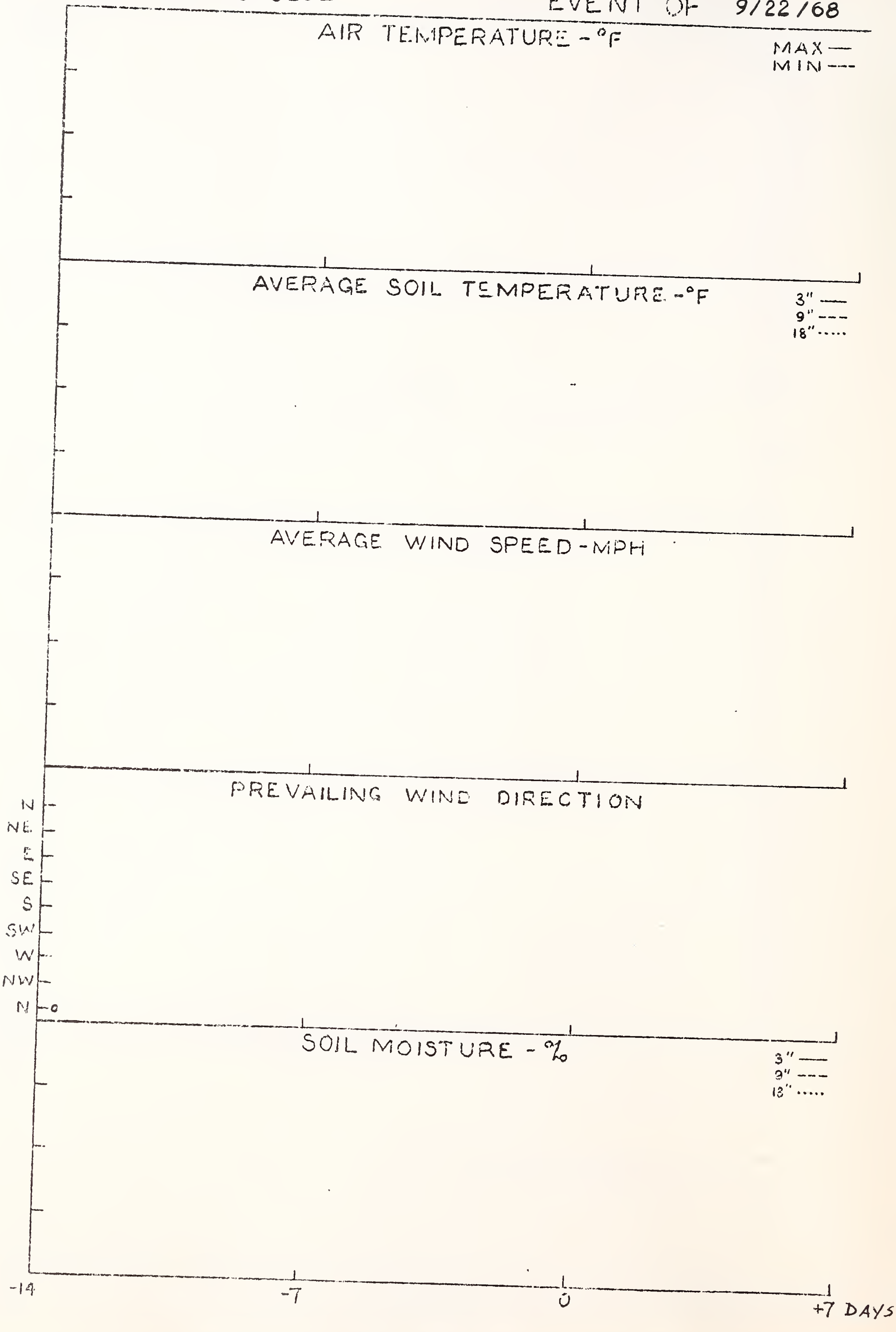


LONE MAN COULEE EVENT OF 1/23/68



LONE MAN COULEE

EVENT OF 9/22/68



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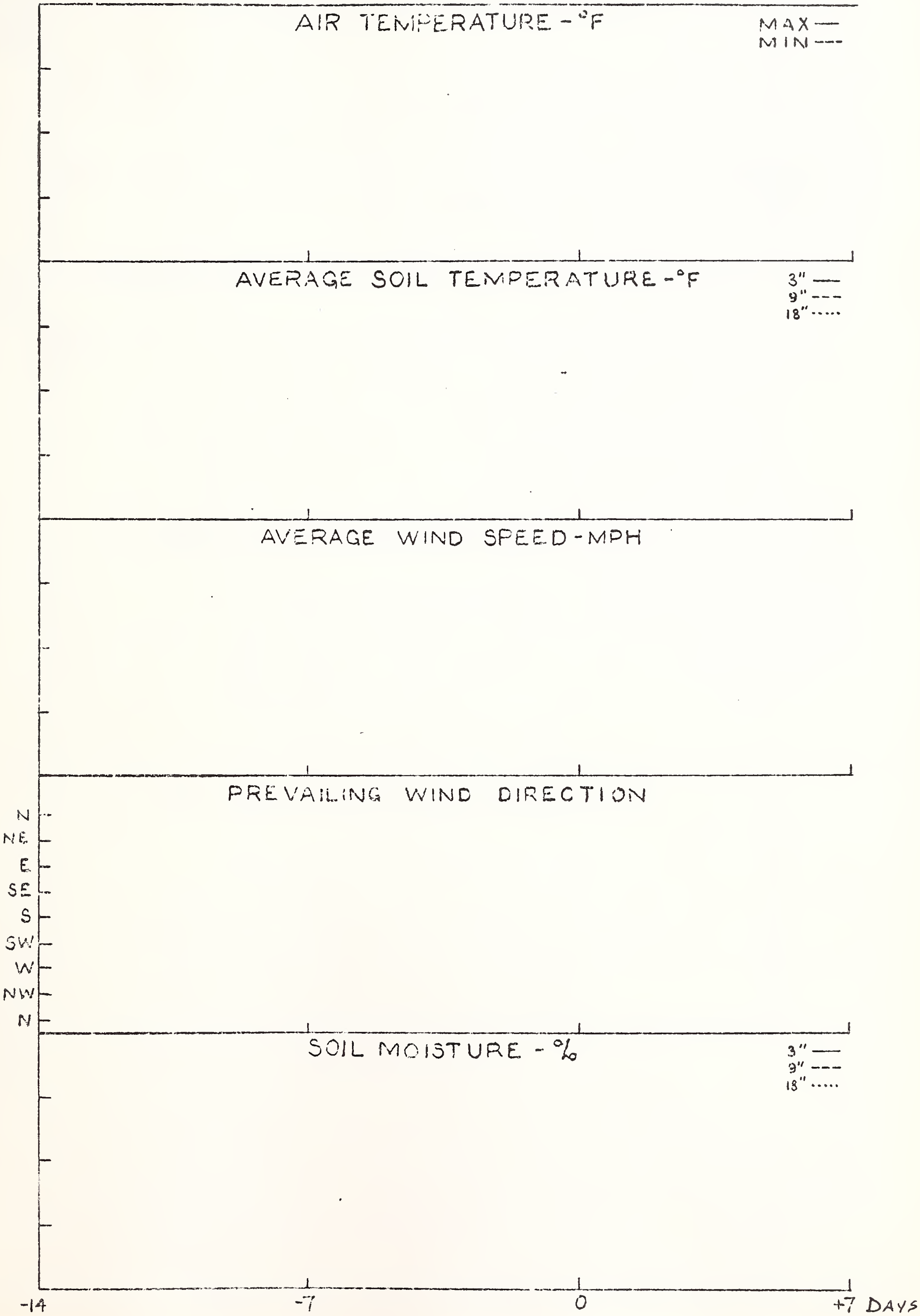

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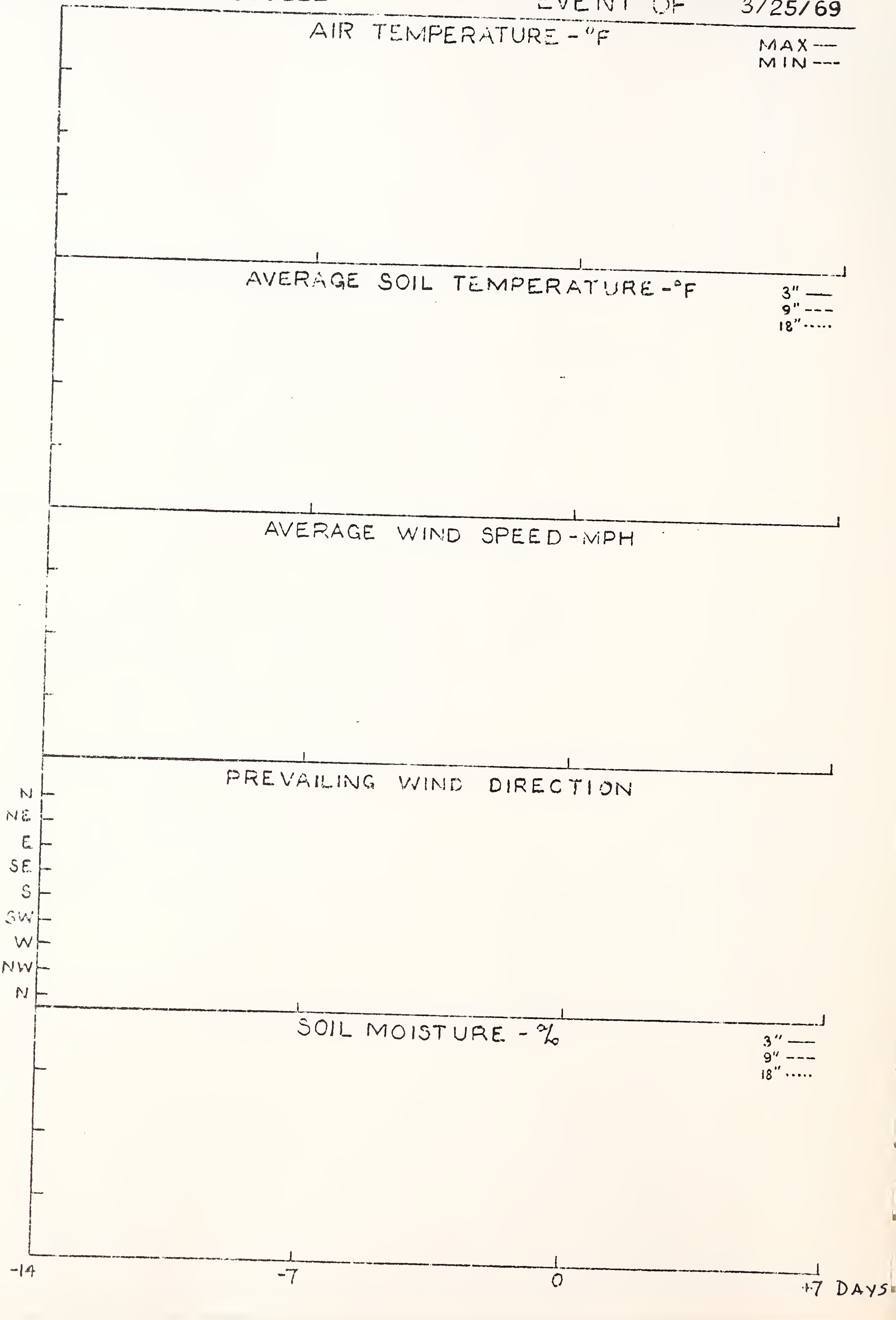
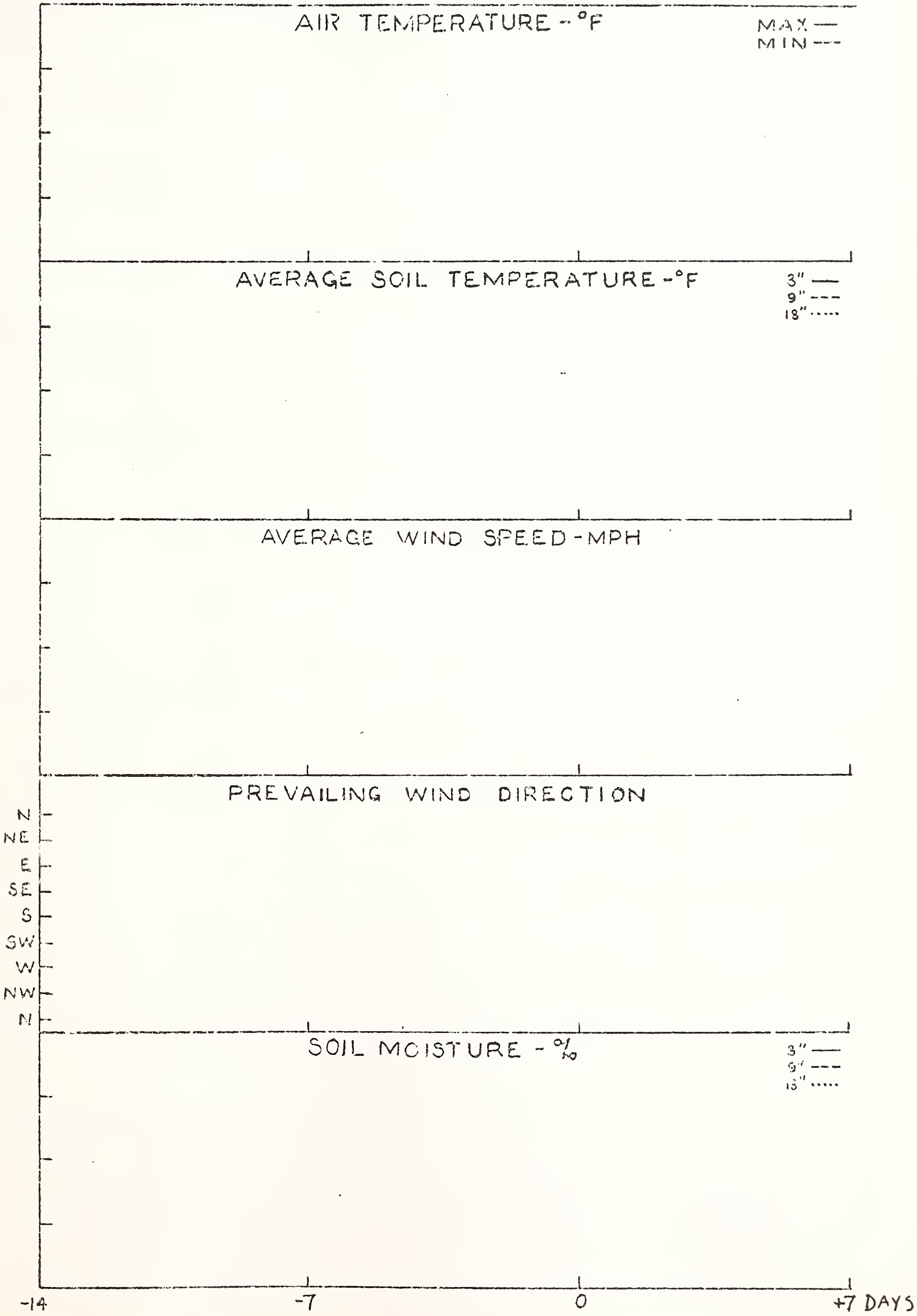


LONE MAN COULEE EVENT OF 3/31/69



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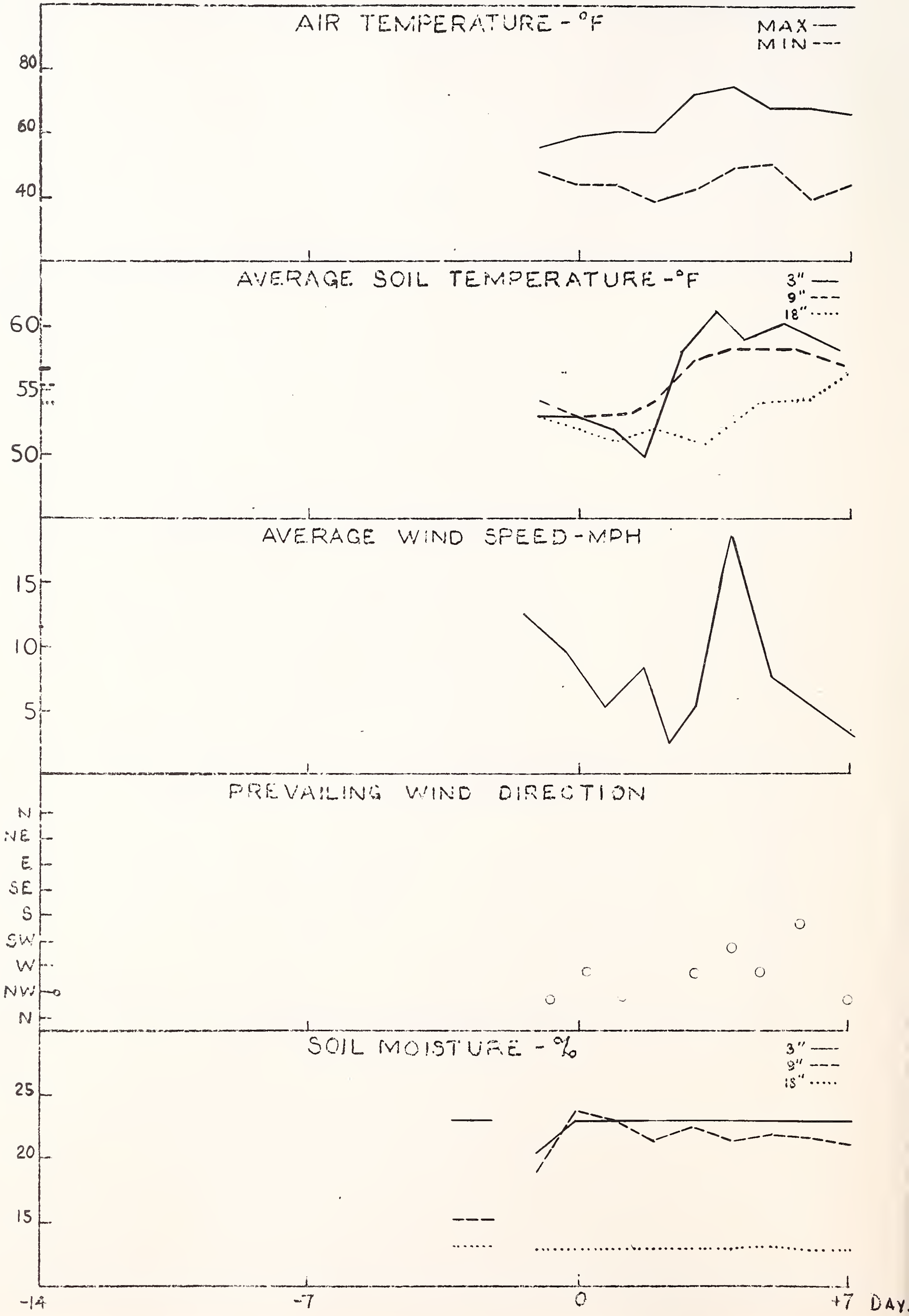


MONTHLY PRECIPITATION TOTALS -- BACON CREEK

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1963													
Robertson									0.33	0.74	0.08	1.19	2.34*
Hiner								0.49	1.29	0.92	0.05	0.07	2.82*
Lode									0.19	0.66	0.03	0.67	1.55*
Nelson								1.47	0.90	0.97	0.22	0.84	4.40*
AVERAGES								0.98	0.68	0.82	0.10	0.69	
1964													
Robertson	0.18	0.00	0.25	0.11	2.37	4.68	0.25	1.93	0.02	0.27	0.53	0.74	11.33
Fulton								2.01	0.00	0.48	0.73	0.59	3.81*
Hiner	0.04	0.02	0.07	0.04	3.29	5.92	0.80	1.70	0.11	0.42	0.24	0.09	12.74
Lode	0.16	0.05	0.16	0.05	3.86	5.90	0.51	1.28	0.07	0.08	0.59	0.73	13.44
Nelson	0.17	0.06	0.14	0.07	1.43	4.86	0.46	1.53	0.02	0.19	0.94	0.77	10.64
AVERAGES	0.14	0.03	0.16	0.07	2.74	5.34	0.51	1.69	0.06	0.29	0.61	0.58	12.04
1965													
Robertson	0.54	0.15	0.38	1.64	1.03	3.21	1.42	1.70	2.30	0.54	0.79	0.15	13.85
Fulton	0.27	0.07	0.10	1.13	1.79	3.88	0.53	2.70	2.68	0.21	0.22	0.13	13.71
Hiner	0.08	0.04	0.10	0.71	1.61	3.67	1.56	2.65	2.75	0.44	0.18	0.03	13.82
Lode	0.09	0.04*	0.00*	0.68	0.60	3.67	0.93	1.74	2.39	0.41	0.18	0.05	10.78*
Nelson	0.24	0.06	0.17	0.94	1.24	3.25	1.28	2.29	3.24	0.35	0.02	0.12	13.20
AVERAGES	0.24	0.08	0.19	1.02	1.25	3.54	1.14	2.22	2.67	0.39	0.27	0.10	13.65
1966													
Blaquiere (Rob'n)	0.17	0.15	0.34	0.00*	0.00*	0.46	0.38	0.46	0.28	0.71	0.95	1.23	5.13*
Fulton	0.05	0.02	0.46	0.81	1.41	1.97	0.76	0.52	0.36	0.37	0.42	0.93	8.08
Hiner	0.07	0.09	0.09	0.13	1.00	2.13	0.50	0.35	0.43	0.13	0.13	0.19	5.24
Lode	0.12	0.11	0.26	0.78	1.31	1.77	1.05	0.48	0.14	0.50	0.54	0.78	7.84
Nelson	0.43	0.27	0.26	0.72	1.76	2.02	0.95	0.53	0.51	0.78	0.92	0.54	9.69
AVERAGES	.09	0.13	0.28	0.61	1.37	1.67	0.73	0.47	0.34	0.50	0.59	0.73	7.71
1967													
Blaquiere	0.42	0.32	0.87	0.00*	3.15*	5.52*	0.65*	0.35	0.36*	0.68	0.36	0.25	12.93*
Fulton	0.14	0.13	0.53	0.78	3.78	5.04	1.24	0.51	1.15	1.23	0.57	0.08	15.18
Hiner	0.09	0.03	0.57	1.34	4.41	5.10	0.11	0.65	0.66	1.25	0.24	0.05	14.50
Lode	0.55	0.17	0.85	0.38	3.83	3.64*	0.63	0.97*	0.49	0.87	0.31*	0.21	12.90*
Nelson	0.54	0.11	1.61	1.08	4.97	3.67	0.93	1.12	0.78	1.32	0.21	0.24	16.58
AVERAGES	0.35	0.15	0.88	0.90	4.25	4.60	0.73	0.66	0.77	1.07	0.35	0.17	15.42

* - Some data missing; not included in averages

MONTHLY PRECIPITATION TOTALS -- BACON CREEK

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1968													
Blaquiere	0.25*	0.05	0.34	0.29*	2.80*	4.68*	1.33*	0.81*	1.09*	1.05*	2.55*	0.29*	15.43*
Fulton	0.78	0.09	0.22	0.29	3.37	5.42	0.89	1.31	1.69	0.69	1.29	0.41	16.45
Hiner	0.36	0.09	0.13	0.22	4.06	5.47	0.98	0.67	0.38	1.45	2.01	0.05	15.87
Lode	0.08	0.04	0.00*	0.16	1.53	4.66*	0.44	0.67*	1.29*	0.35	0.88	0.16	10.26*
Nelson	0.22	0.06	0.16	0.14	3.30	4.21	1.39	0.86	1.71	0.52	0.98	0.38	13.93
AVERAGES	0.36	0.07	0.21	0.20	3.07	5.03	0.93	0.95	1.26	0.75	1.29	0.25	15.42
1969													
Blaquiere	1.27*	0.00	0.35	0.15*	0.00*	0.81*	0.27*	0.00*	0.00*				2.85*
Fulton	1.55	0.05	0.54	0.15	0.69	2.98	1.84	0.64					8.44*
Hiner	0.45	0.03	0.05	0.07	0.75	4.69	0.85	1.01					7.90*
Lode	0.59	0.11	0.07	0.12	1.01	2.83	1.21	1.11					7.05*
Nelson	1.64	0.03	0.10	0.17	1.15	2.77	1.14	0.95	0.05				8.00*
AVERAGES	1.06	0.06	0.22	0.13	0.90	3.32	1.26	0.93	0.05				
1970													
Blaquiere				0.90*	3.18	1.13							5.21*
Fulton				0.54	4.68	1.42							6.64*
Hiner				0.65	4.41	1.37							6.43*
Lode				0.00*	3.72*	1.28*							5.00*
Nelson				0.78	5.95	1.37							8.10*
AVERAGES				0.66	4.56	1.32							

* - Some data missing; not included in averages

MONTHLY PRECIPITATION TOTALS -- DUCK CREEK

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1963													
Dunlap									0.00	0.00	0.00	0.24	0.24*
Allen									0.28	0.00	0.00	0.21	0.49*
Hauk									0.00	0.01	0.01	0.27	0.29*
Jonas									0.00	0.00	0.00	0.16	0.16*
Jordan									0.00	0.00	0.00	0.14	0.14*
Schwab									0.00	0.00	0.00	0.30	0.30*
Ueland, F.									0.00	0.00	0.00	0.17	0.17*
AVERAGES									0.04	0.00	0.00	0.21	
1964													
Meissner (Dunlap)	0.31	0.64	0.63	1.26	3.34	3.16	2.33	1.28	0.09	0.42	1.11	0.10	14.67
Allen	0.27	0.10	0.27	1.48	2.41	2.22	2.85	1.87	0.00	0.48	0.86	0.22	13.03
Hauk	0.25	0.12	0.27	1.43	2.29	3.21	2.15	3.11	0.14	0.82	0.77	0.16	14.72
Jonas	0.41	0.12	0.45	1.50	2.09	3.24	1.05	2.04	0.38	0.30	0.36	0.25	12.19
Jordan	0.20	0.18	0.27	1.60	2.18	2.96	1.60	1.11	0.12	0.36	0.36	0.18	11.12
Schwab	0.57	0.39	0.49	1.54	2.28	3.37	1.40	2.58	0.22	0.52	0.51	0.00*	13.87*
Ueland, F.	0.31	0.15	0.21	1.31	1.85	2.59	1.91	1.77	0.12	0.37	0.41	0.19	11.49
AVERAGES	0.33	0.24	0.37	1.45	2.35	2.96	1.90	1.97	0.15	0.47	0.63	0.18	12.87
1965													
Meissner	0.35	0.07	0.41	1.20	1.61	5.00	3.82	3.36	1.09	0.00	0.09	0.00	17.00
Allen	0.14	0.02	0.21	0.98	3.42	5.64	2.53	3.06	1.17	0.00	0.00	0.00	17.17
Hauk	0.24	0.10	0.31	0.87	3.22	5.45	1.88	2.60	1.47	0.00	0.01	0.02	16.17
Jonas	0.55	0.05	0.34	1.54	3.47	4.80	1.46	1.65	1.74	0.00	0.13	0.06	15.79
Jordan	0.21	0.07	0.32	1.19	3.19	3.92	1.61	1.87	0.78	0.00	0.02	0.00	13.18
Ueland, C. (Schwab)	0.00	0.06	0.60	1.43	0.00*	0.41	1.09	0.49	1.21	0.00	0.13	0.02	5.44*
Ueland, F.	0.48	0.11	0.56	1.34	3.73	4.54	2.30	3.19	1.26	0.00	0.14	0.09	17.74
	0.28	0.07	0.39	1.22	3.11	4.25	2.10	2.32	1.25	0.00	0.07	0.03	16.18
1966													
Meissner	0.08	0.10	0.00	0.73	1.00	2.49	1.52	2.57	0.94	0.40	0.29	0.00	10.12
Allen	0.19	0.09	0.03	0.46	0.80	2.75	2.81	2.01	1.05	0.31	0.31	0.09	10.90
Hauk	0.06	0.10	0.30	0.35	0.88	2.81	4.00	2.34	1.39	0.38	0.10	0.03	12.74
Jonas	0.39	0.32	0.51	1.04	1.03	4.17	1.99	2.40	0.56	0.47	0.28	0.00*	13.16*
Jordan	0.22	0.09	0.04	0.56	1.06	2.37	1.29	1.57	0.33	0.26	0.34	0.04	8.15
Ueland, C.	0.25	0.18	0.00	0.42	0.99	3.18	0.46	2.01	0.14	0.28	0.41	0.19	8.51
Ueland, F.	0.30	0.16	0.39	0.66	0.82	4.05	1.64	2.09	0.62	0.42	0.42	0.22	11.79
AVERAGES	0.21	0.15	0.18	0.60	0.94	3.18	1.96	2.14	0.72	0.36	0.31	0.10	10.37

* - Some data missing; not included in averages

MONTHLY PRECIPITATION TOTALS -- DUCK CREEK

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1967													
Meissner	0.00	0.00	0.57	1.29	1.24	1.74	0.96	0.00*	4.88	0.23	0.00	0.17*	11.08*
Grist (Allen)	0.08	0.12	0.37	1.58	1.12	1.41	0.92	0.00	3.73	0.16	0.05	0.06	9.60
Hauk	0.07	0.03	0.09	1.04	2.45	2.08	1.49	0.00	4.18	0.42	0.00	0.25	12.10
Jonas	0.04	0.14*	0.92	0.85	0.00*	0.00*	1.07	0.00	3.58	0.26	0.29	0.00*	7.15*
Jordan	0.28	0.20	0.60	1.50	1.02	1.51*	0.96	0.02	3.06	0.35	0.05	0.18	9.73*
Ueland, C.	0.53	0.18	1.04	1.12	0.56	2.57*	0.65*	0.00	3.86	0.44	0.00*	0.00*	10.95*
Ueland, F.	0.32	0.38	1.11	1.74	1.97*	1.66*	0.72	0.00	3.69	0.25*	0.06*	0.30	12.20*
AVERAGES	0.19	0.15	0.67	1.30	1.28	1.74	1.02	0.00	3.85	0.31	0.08	0.20	10.85
1968													
Meissner	0.26	0.00	0.24	0.10	1.03	3.97	0.79	3.47	0.31	0.20	0.34	4.08	14.79
Grist	0.15	0.08	0.47	0.06	1.48	4.27	1.25	2.95	0.38	0.01	0.22	0.29	11.61
Hauk	0.30	0.01	0.65	0.30	1.71	5.22	0.98	1.68	0.33	0.01	0.46	0.32	11.97
Jonas	0.19	0.09	0.00*	0.00*	0.00*	3.06	0.02	3.20	0.05	0.01	0.42	0.00*	7.04*
Jordan	0.05	0.11	0.42	0.22	0.45	3.52*	0.77	1.64*	0.55	0.06	0.27*	0.34	8.40*
Ueland, C.	0.00*	0.00*	0.00*	0.00*	0.00*	3.45	0.44	4.08	0.45	0.09	0.30	1.04*	9.85*
Ueland, F.	0.47	0.15	0.65	0.62*	1.19*	3.22	0.21*	3.26	0.36*	0.00	0.21*	0.77*	11.11*
AVERAGES	0.24	0.07	0.49	0.17	1.17	3.87	0.71	3.11	0.35	0.05	0.35	1.26	12.79
1969													
Dunlap (Meissner)	3.05	0.01*	0.36	2.56	1.59	2.85	2.77	0.57					13.76*
Grist	0.45	0.07	0.18	2.64	2.46	2.65	3.54	0.40					12.39*
Hauk	0.60	0.32	0.20	3.11	2.61	3.33	3.91	0.23					14.31*
Jonas	0.00*	0.15*	0.76	2.26	2.82	3.10	4.43	0.29	0.28*				14.09*
Jordan	0.25*	0.00*	0.15*	1.68	1.24*	1.85*	3.45	0.19*	0.27*				9.08*
Ueland, C.	0.63*	0.00*	0.49	4.11	2.02*	2.12*	2.42	0.00*	0.11*				11.90*
Ueland, F.	0.77*	0.10	0.42*	3.74*	1.77*	3.34*	2.91	0.42*					13.47*
AVERAGES	1.37	0.16	0.40	2.73	2.37	2.98	3.35	0.37					
1970													
Dunlap				2.06	1.50								3.56*
Grist				1.57	2.01	1.89							5.47*
Hauk	No 1970 data												
Jonas				1.75*	1.69	2.90							6.34*
Jordan				1.94*									1.94*
Ueland, C.				2.32*	2.11*	1.14							5.57*
Ueland, F.				2.01*	1.09	1.98*							5.08*
AVERAGES				1.82	1.57	1.98							

* - Some data missing; not included in averages

MONTHLY PRECIPITATION TOTALS -- HUMP CREEK

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1963													
Cain									0.55	0.08	0.04	1.75	2.42*
Krone								0.01	1.65	0.27	0.07	1.28	3.28*
AVERAGES								0.01	1.10	0.18	0.06	1.52	
1964													
Cain	0.00	0.00	0.51	2.28	2.08	4.13	0.28	0.97	0.04	0.00	0.44	0.62	11.35
Mysse (Krone)	0.03	0.00*	0.00*	4.00*	0.00*	0.00*	0.00*	0.73	0.00	0.27	0.64	0.31	5.98*
AVERAGES	0.02	0.00	0.51	3.14	2.08	4.13	0.28	0.85	0.02	0.14	0.54	0.46	11.35
1965													
Cain	0.82*	0.81	0.69	3.49*	1.81	2.31	0.94	2.42*	2.20*	0.30	0.07	0.00*	15.86*
Mysse	0.61	0.76	0.86	2.57	2.54	2.10	0.45	3.75	3.19	0.82	0.12	0.72	18.49
AVERAGES	0.61	0.78	0.78	2.57	2.18	2.20	0.70	3.75	3.19	0.56	0.10	0.72	18.49
1966													
Cain	0.00*	0.18*	0.00*	2.69	2.42	1.42*	1.54*	1.55*	1.96*	0.85*	1.15	0.12	13.88*
Mysse	0.28	0.26	0.91	2.44	2.44	0.82	1.51	1.49	1.78	1.19	1.34	0.32	14.78
AVERAGES	0.28	0.26	0.91	2.56	2.43	0.82	1.51	1.49	1.78	1.19	1.24	0.22	14.78
1967													
Cain	0.00*	2.53*	0.00*	1.35*	4.72*	5.04*	1.59	0.03*	0.56*	0.75*	0.00*	0.00*	16.57*
Mysse	0.19	0.63	1.75	1.12	2.87	8.59	1.51	0.12	0.80	0.86	0.85	0.51	19.80
AVERAGES	0.19	0.63	1.75	1.12	2.87	8.59	1.55	0.12	0.80	0.86	0.85	0.51	19.80
1968													
Cain	1.50*	0.00*	1.07*	0.00*	2.54*	0.00*	0.00*	1.87*	2.16*	1.27*	0.45*	0.00*	10.86*
Mysse	1.01	0.25	1.47	1.59	2.25	6.09	0.25	1.12	2.04	0.72	1.30	0.69	18.78
AVERAGES	1.01	0.25	1.47	1.59	2.25	6.09	0.25	1.12	2.04	0.72	1.30	0.69	18.78
1969													
Cain	0.00*	0.00*	0.18*	0.73*	1.79*	4.39*	0.18*	0.00*	0.00*				7.27*
Mysse	1.21	0.09	0.37	0.99	2.05	3.70	0.87	0.13					9.41*
AVERAGES	1.21	0.09	0.37	0.99	2.05	3.70	0.87	0.13					
1970													
Cain				2.04*	1.62*	1.87*							5.53*
Mysse				2.79	5.09	1.37							9.25*
AVERAGES				2.79	5.09	1.37							

* - Some data missing; not included in averages

MONTHLY PRECIPITATION TOTALS -- LONE MAN COULEE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1963													
Geiger									0.96	0.26	0.00	0.23	1.45*
Gossard								0.52*	0.94	0.29	0.05	0.35	2.15*
Toren, J.									1.01	0.20	0.03	0.18	1.42*
Vanden Bos								0.48*	1.02	0.12	0.00*	1.02	2.64*
AVERAGES									0.98	0.42	0.03	0.45	
1964													
Geiger	0.16	0.21	0.84	2.61	5.53	6.10	1.58	0.63	0.60	0.17	0.00*	1.16*	19.59*
Field (Gossard)	0.23	0.14	0.96	2.37	6.50	6.86	2.02	0.77	0.61*	0.00*	0.12	1.27	21.85*
Toren, J.	0.14	0.09	0.64	1.67	5.46	5.29	1.17	0.67	0.32	0.13	0.35	1.01	16.94
Vanden Bos	0.90	0.09	0.65	1.85	6.74	5.33	2.09	0.61	0.68	0.00	0.15	1.52*	20.61*
AVERAGES	0.36	0.13	0.77	2.13	6.06	5.90	1.72	0.67	0.53	0.10	0.21	1.14	16.94
1965													
Geiger	0.46	0.41	0.63	1.23	1.16	5.42	1.42	0.91	1.74	0.00	0.18	0.26	13.82
Field	0.25	0.31	0.64	1.16	1.23	6.00	1.59	1.63	1.72	0.02	0.15	0.10	14.80
Toren, J.	0.32	0.37	0.35	1.29	0.67	5.13	1.84	0.93	1.11	0.00	0.35	0.13	12.49
Vanden Bos	0.08	0.04	0.16	0.44	0.81	5.21	1.34	1.10	0.00*	0.00*	0.02	0.01	9.21*
AVERAGES	0.28	0.28	0.45	1.03	0.97	5.44	1.55	1.14	1.14	0.00	0.18	0.13	13.70
1966													
Geiger	0.46	0.26	0.27	0.90	0.87	2.36	1.56	1.88	0.30	0.98	0.93	0.34	11.11
Field	0.42	0.27	0.21	0.65	0.78	2.87	1.60	2.16	0.36	1.03	1.15	0.54	12.04
Toren, J.	0.30	0.18	0.07	0.31	0.75	2.48	1.57	1.19	0.19	0.74	0.69	0.35	8.82
Vanden Bos	0.31	0.11	0.00	0.12	1.70	3.01	1.75	1.39	0.26	0.87	0.10*	0.00	9.62*
AVERAGES	0.37	0.21	0.14	0.50	1.03	2.68	1.62	1.66	0.28	0.91	0.23	0.41	10.66
1967													
Geiger	0.65	0.19	0.65	2.60	2.59	3.22	0.26	0.09	0.35	0.32	0.65	0.74	12.31
Field	0.19	0.12	0.43	2.60	2.52	3.34	0.29	0.04	0.58	0.35	0.65	0.63	11.74
Toren, J.	0.28	0.16	0.41	1.71	1.68	2.41	0.29	0.27	0.43	0.36	0.50	0.54	9.04
Vanden Bos	0.00	0.00	0.19	0.45*	1.45	3.27	0.00	0.00	0.50	0.05	0.00*	0.22*	6.13*
AVERAGES	0.28	0.12	0.42	2.34	2.06	3.06	0.21	0.10	0.47	0.27	0.60	0.64	11.03

* - Some data missing; not included in averages

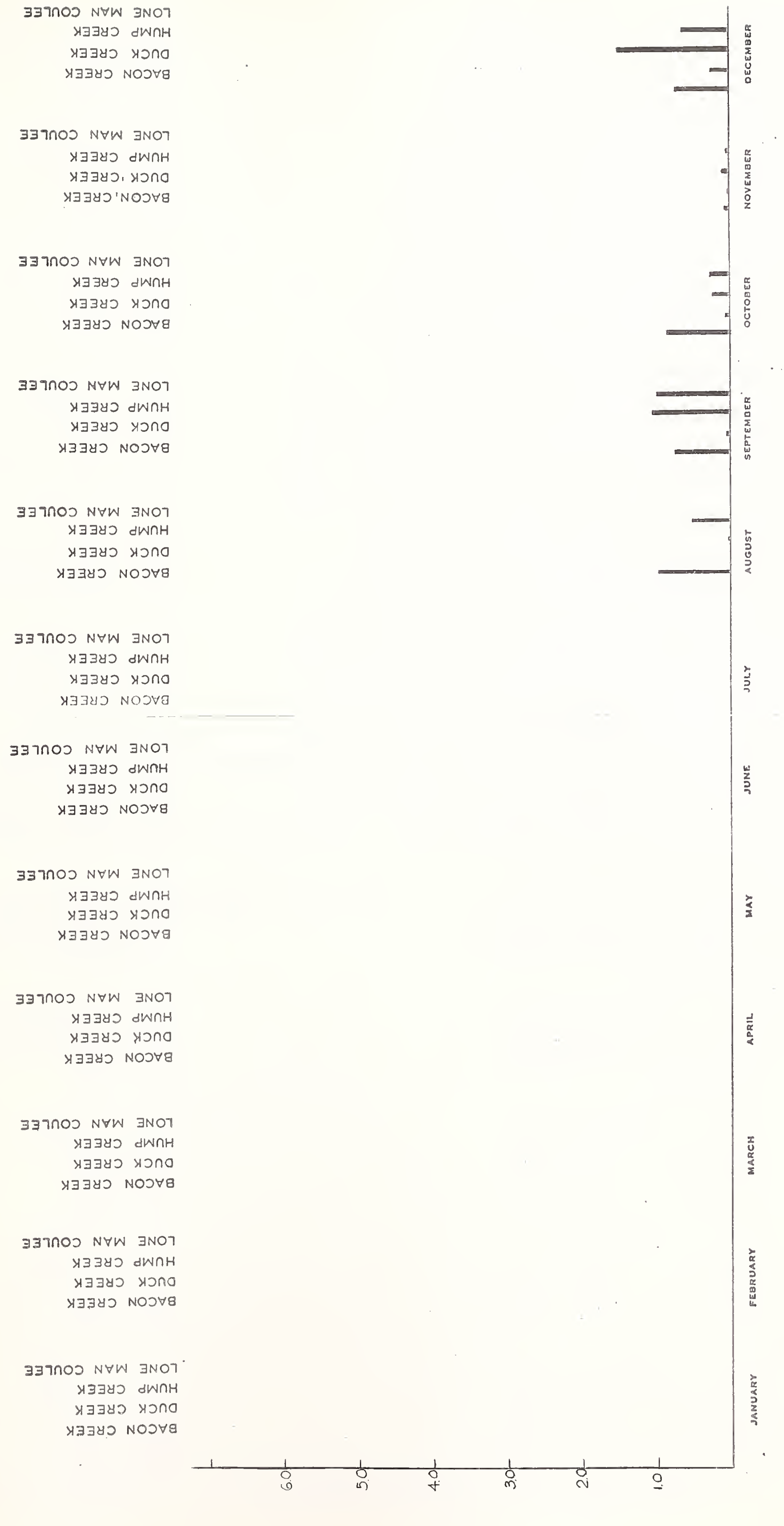
MONTHLY PRECIPITATION TOTALS -- LONE MAN COULEE

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	TOTAL
1968													
Geiger	0.46*	0.08	0.21	0.53	2.08*	1.93	0.17	2.41	2.76	0.14	0.48	0.45	11.70*
Field	0.47	0.00	0.20	0.52	1.81	2.45	0.22	2.90	3.82	0.12	0.43	0.67	13.61
Toren,D. (Toren,J)	0.42	0.13	0.14	0.22*	1.63*	2.42*	0.15	2.30	2.68	0.03	0.41	0.05	10.58*
Vanden Bos	0.02*	0.00*	0.00*	0.00*	1.58	3.05	0.00*	3.47	0.80	0.45	0.70	0.09	10.16*
AVERAGES	0.45	0.07	0.18	0.53	1.95	2.48	0.18	2.77	2.52	0.18	0.51	0.32	13.61
1969													
Geiger	0.17	0.08	0.24	0.25	0.38	5.30	0.23	0.05	0.07				6.77*
Field	0.84	0.08	0.27	0.33	0.65	6.81	0.57	0.02					9.57*
Toren, D.	0.19	0.05	0.05	0.09	0.30	3.93	0.17	0.13					4.91*
Vanden Bos	0.29	0.29	0.70	0.02	0.20	2.95	0.60	0.02					5.07*
AVERAGES	0.37	0.12	0.32	0.18	0.38	4.75	0.39	0.06					

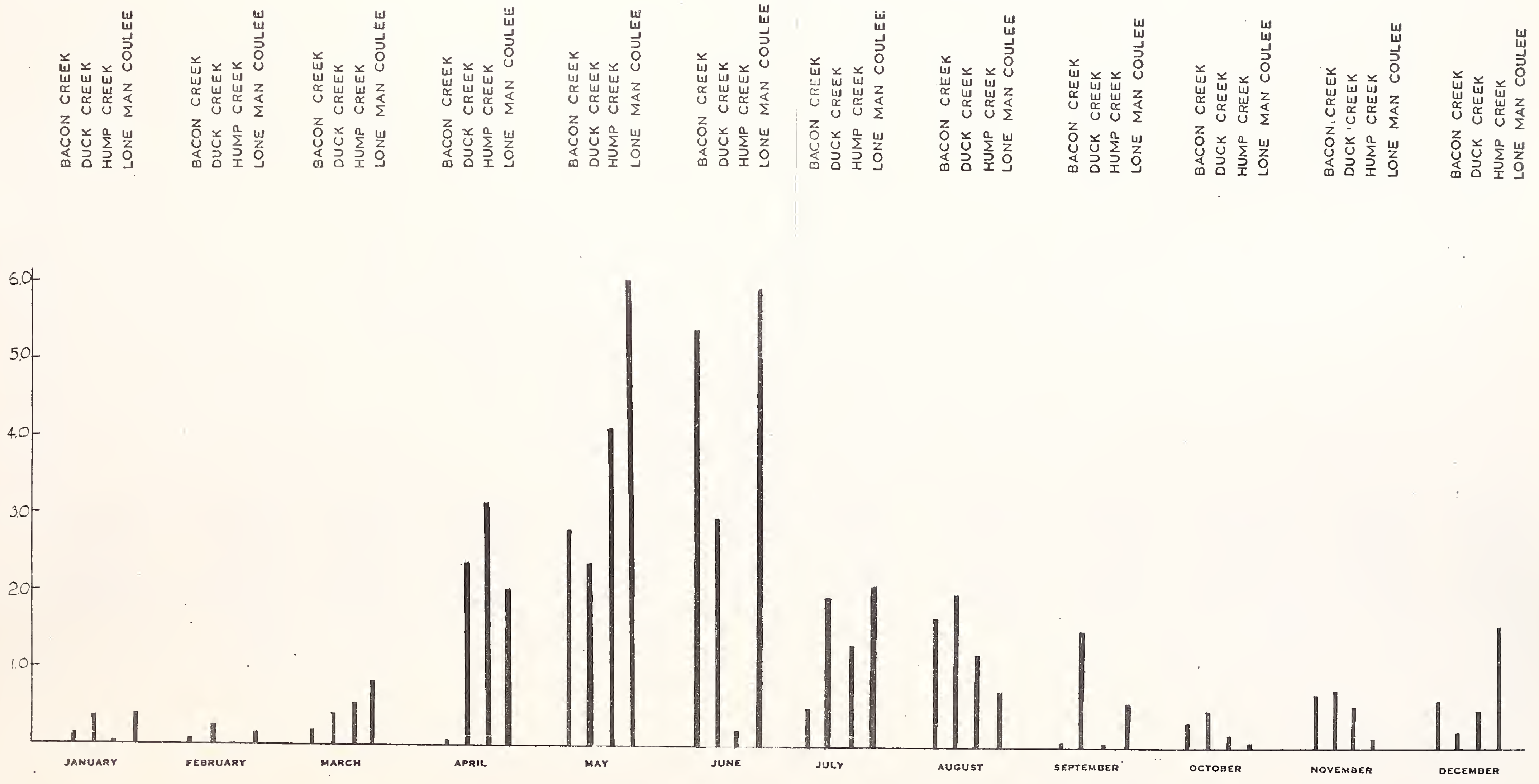
* - Some data missing; not included in averages

MEAN MONTHLY PRECIPITATION

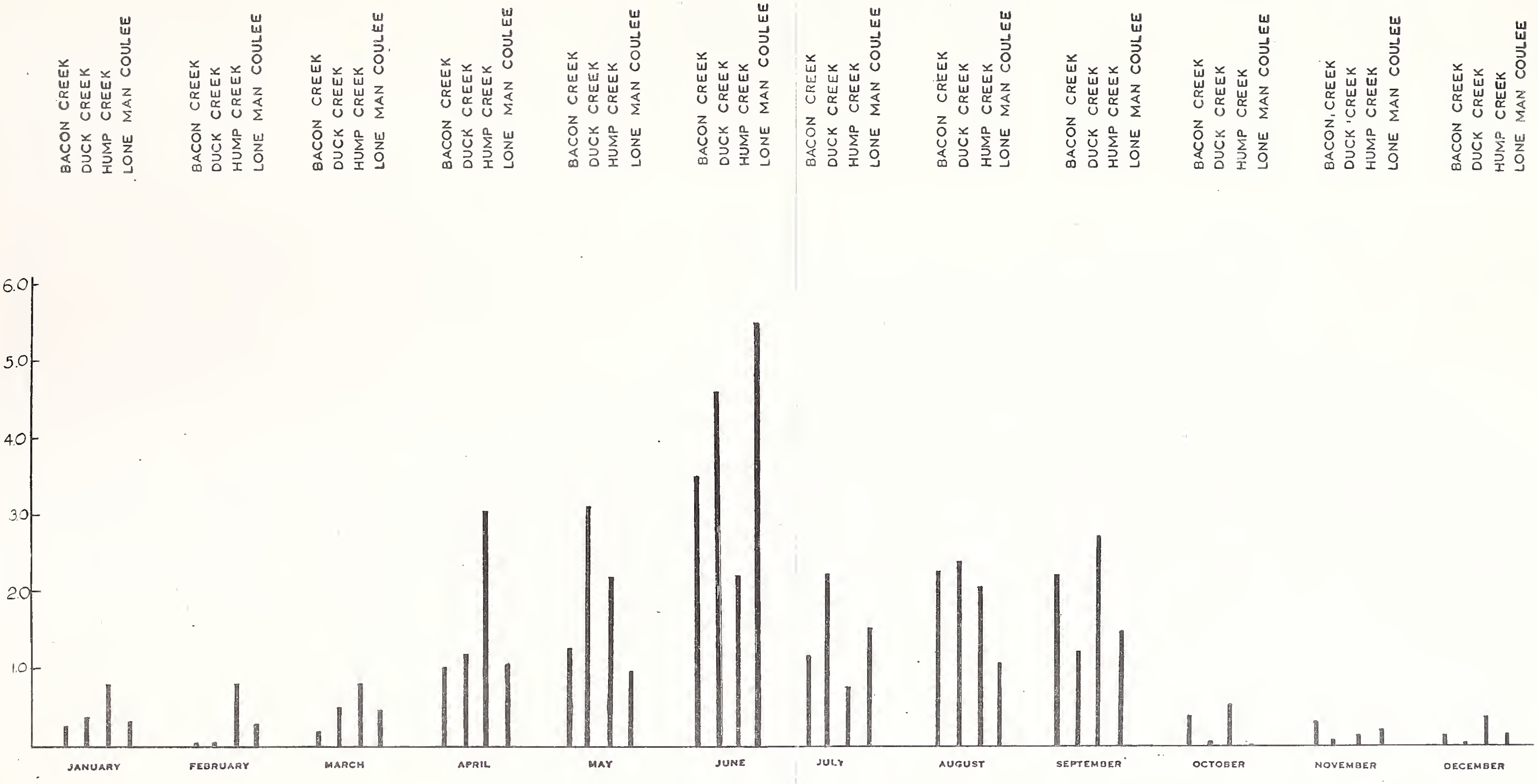
1963



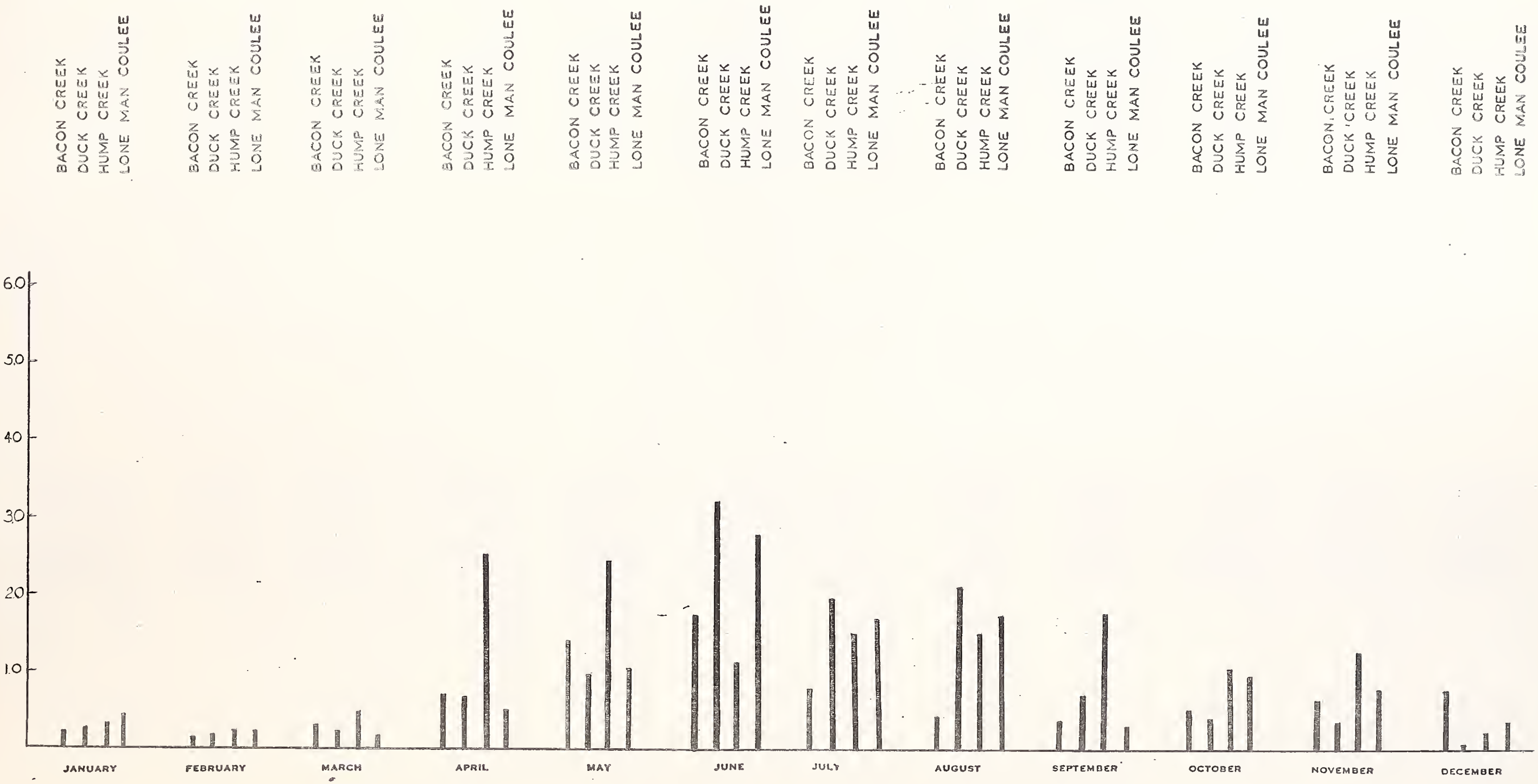
MEAN MONTHLY PRECIPITATION
1964



MEAN MONTHLY PRECIPITATION
1965



MEAN MONTHLY PRECIPITATION
1966



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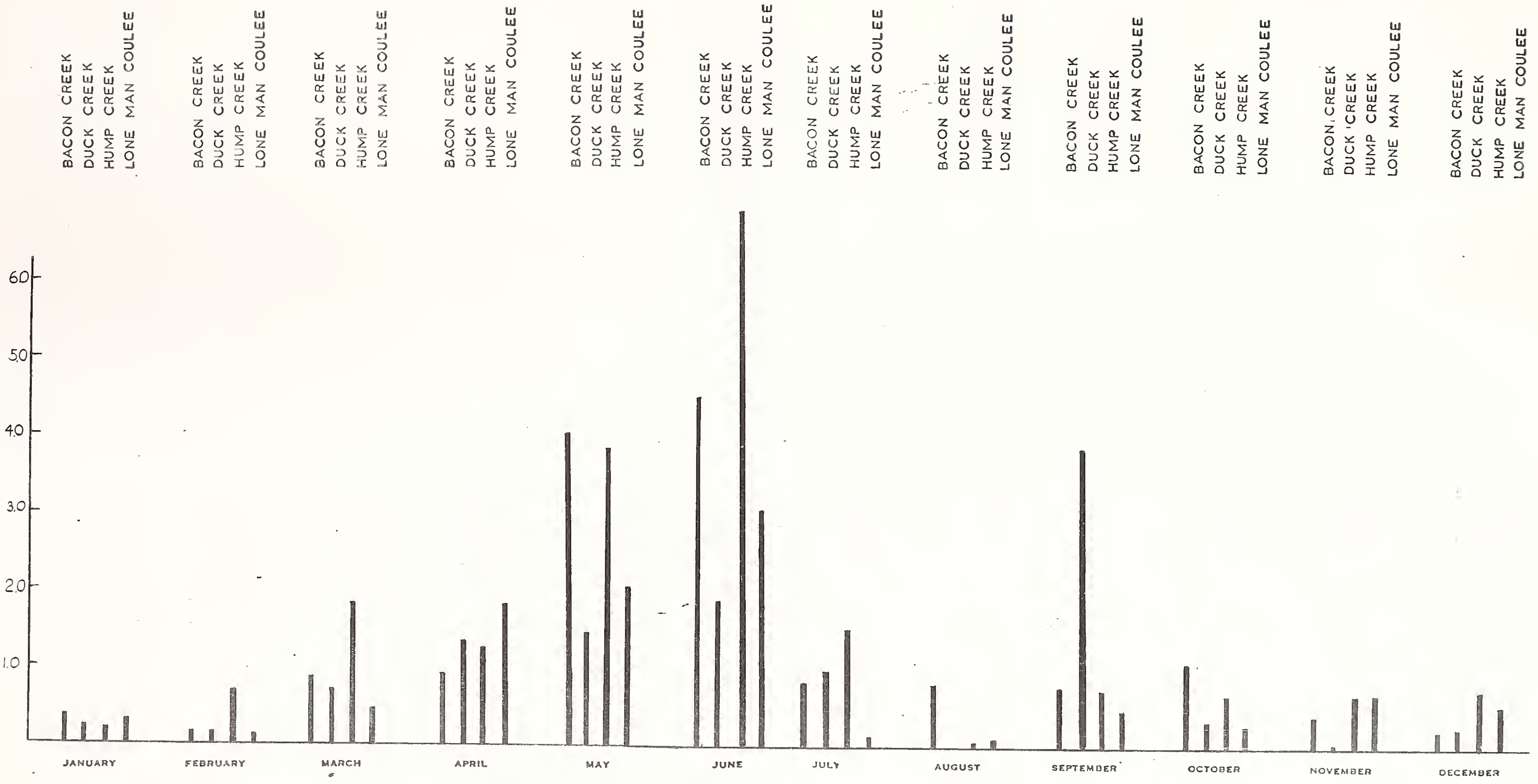
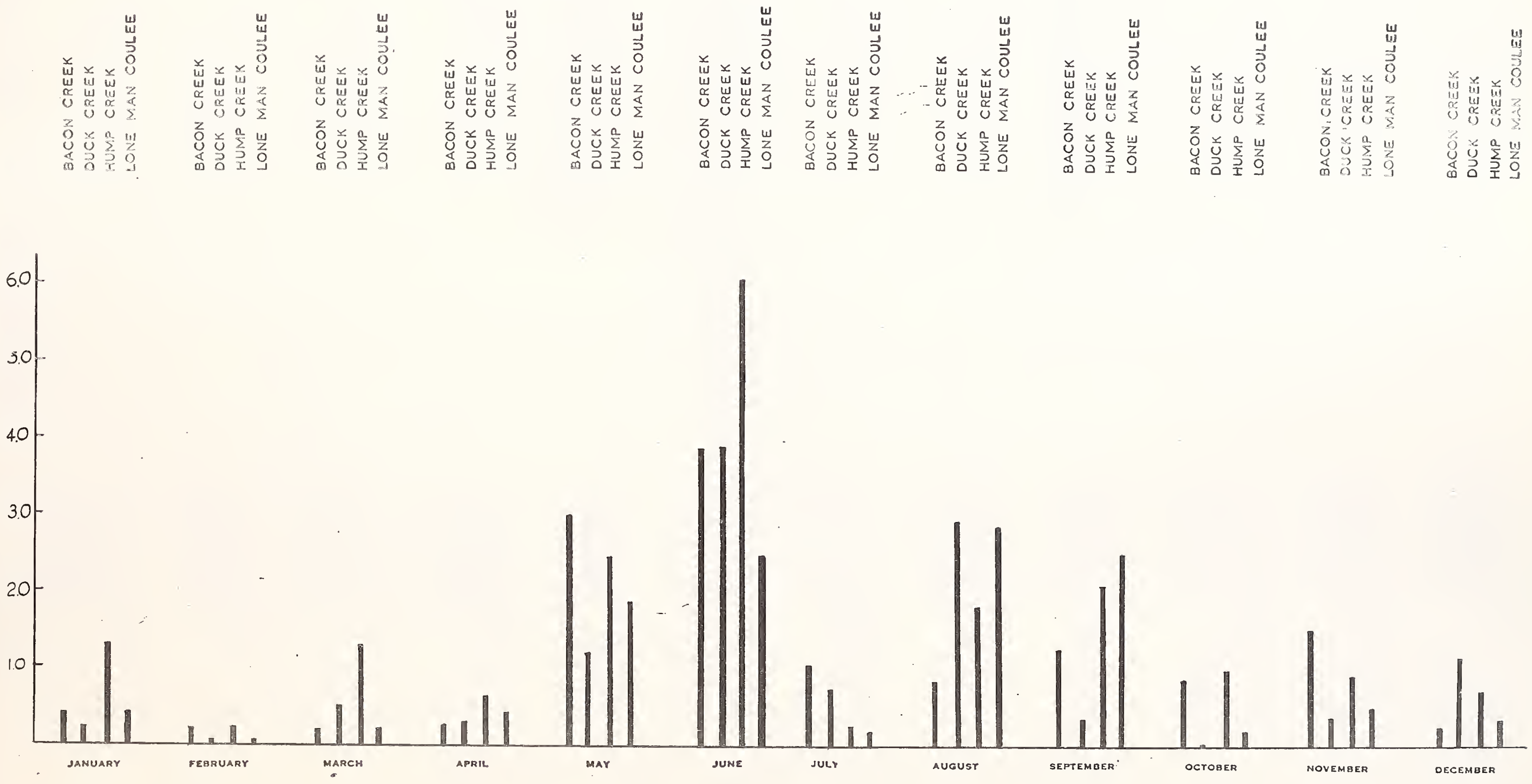
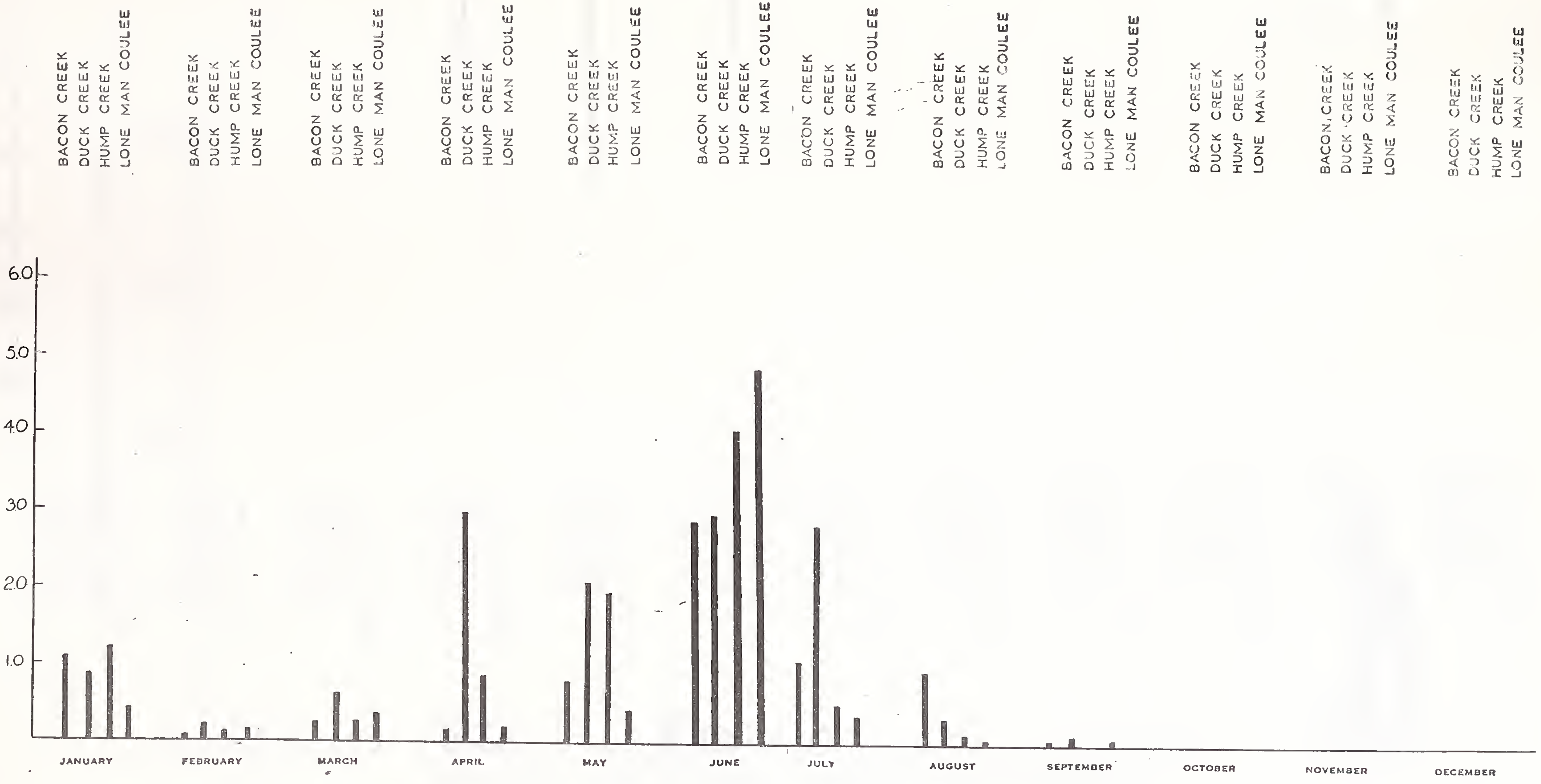
1967



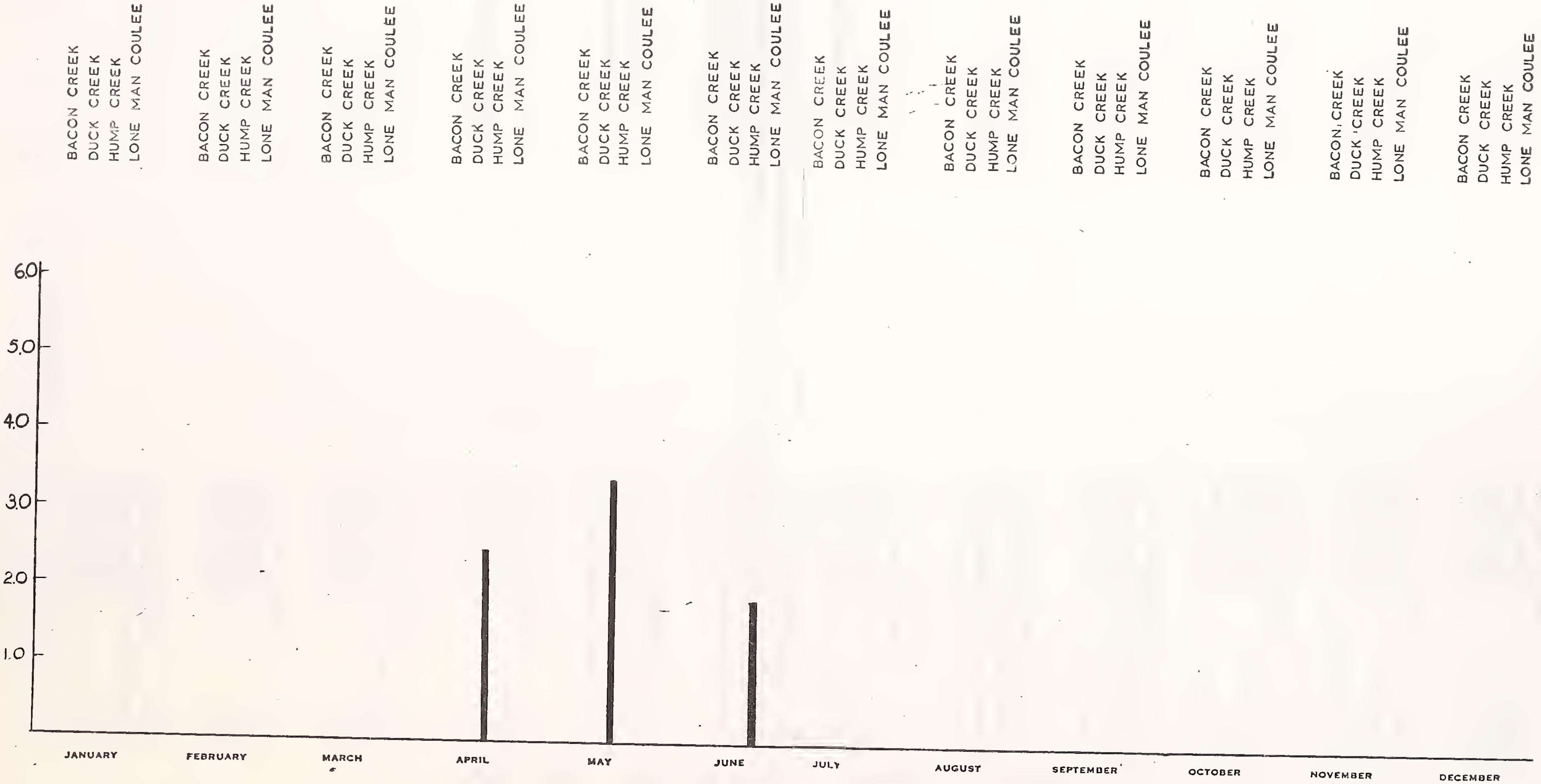
MEAN MONTHLY PRECIPITATION 1968



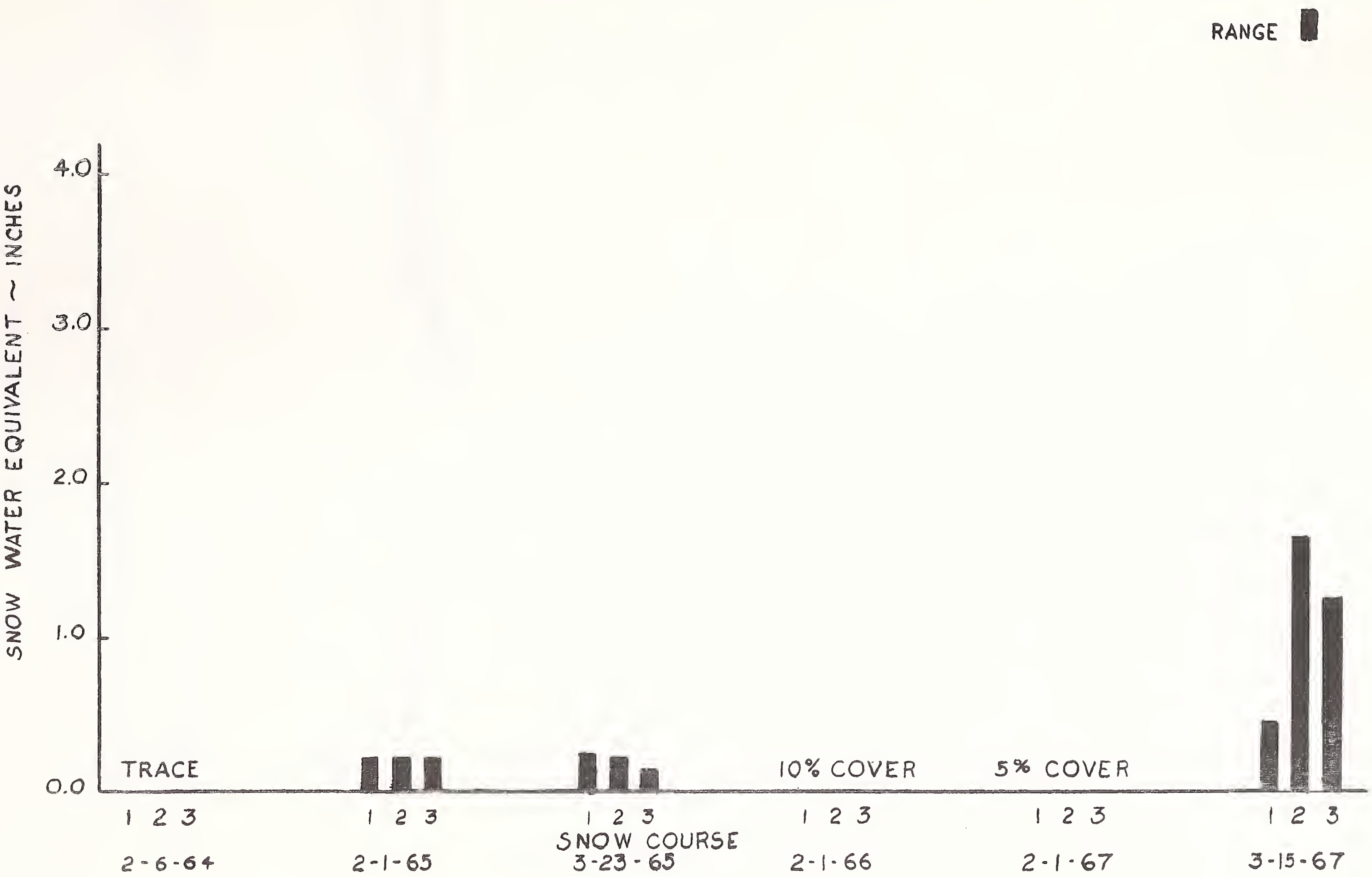
MEAN MONTHLY PRECIPITATION
1969



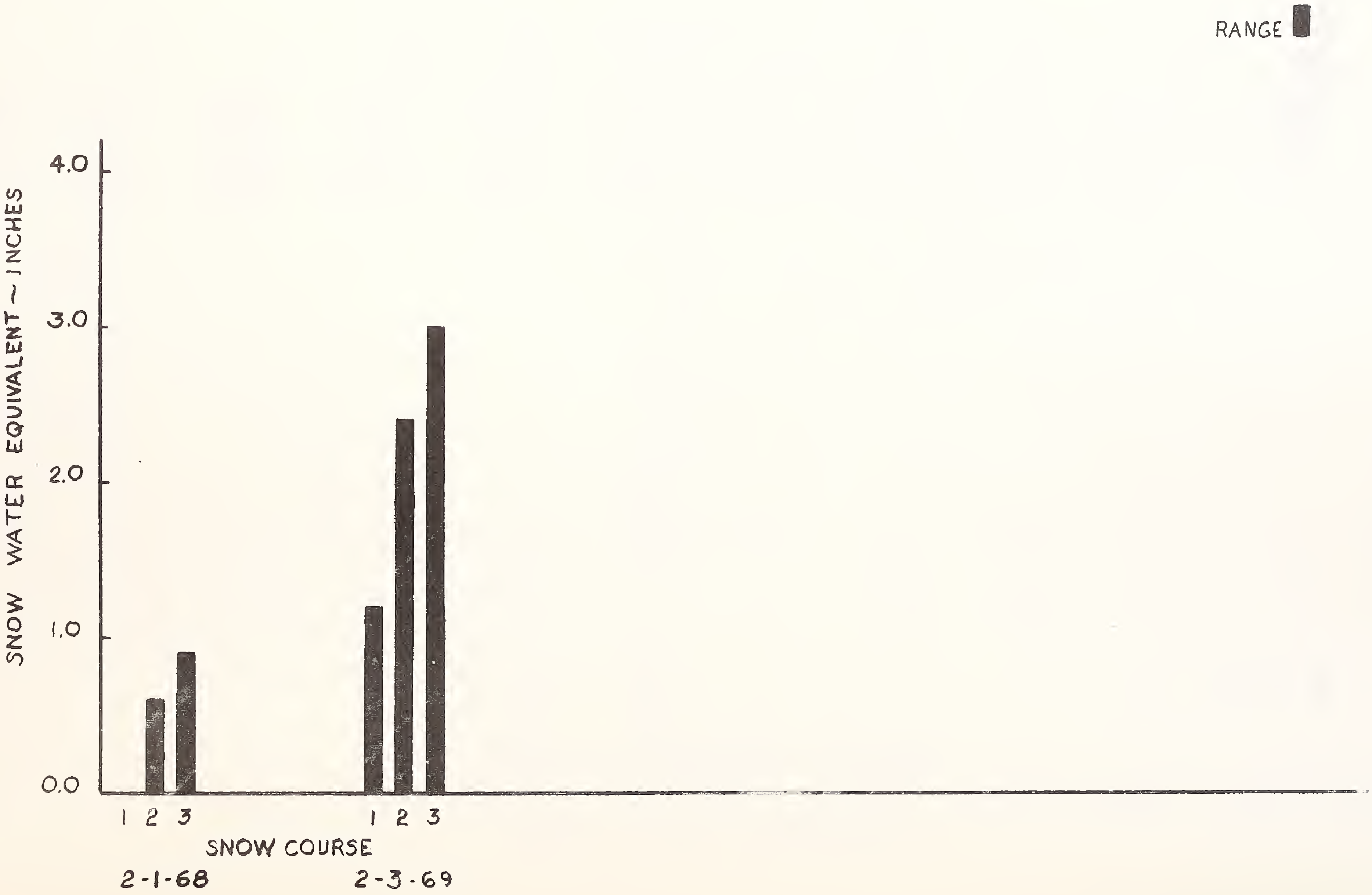
MEAN MONTHLY PRECIPITATION
1970



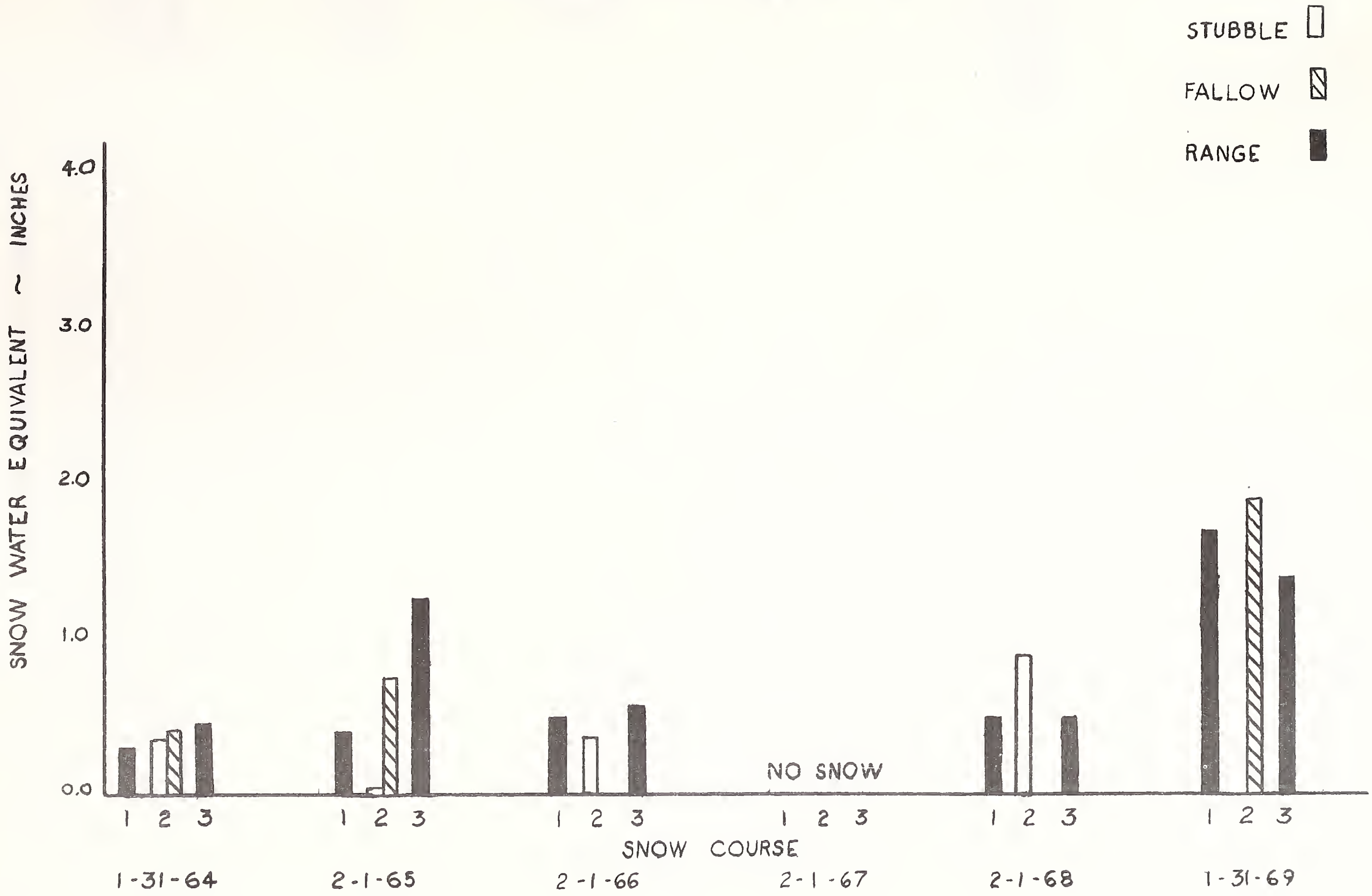
BACON CREEK
SNOW SURVEY DATA



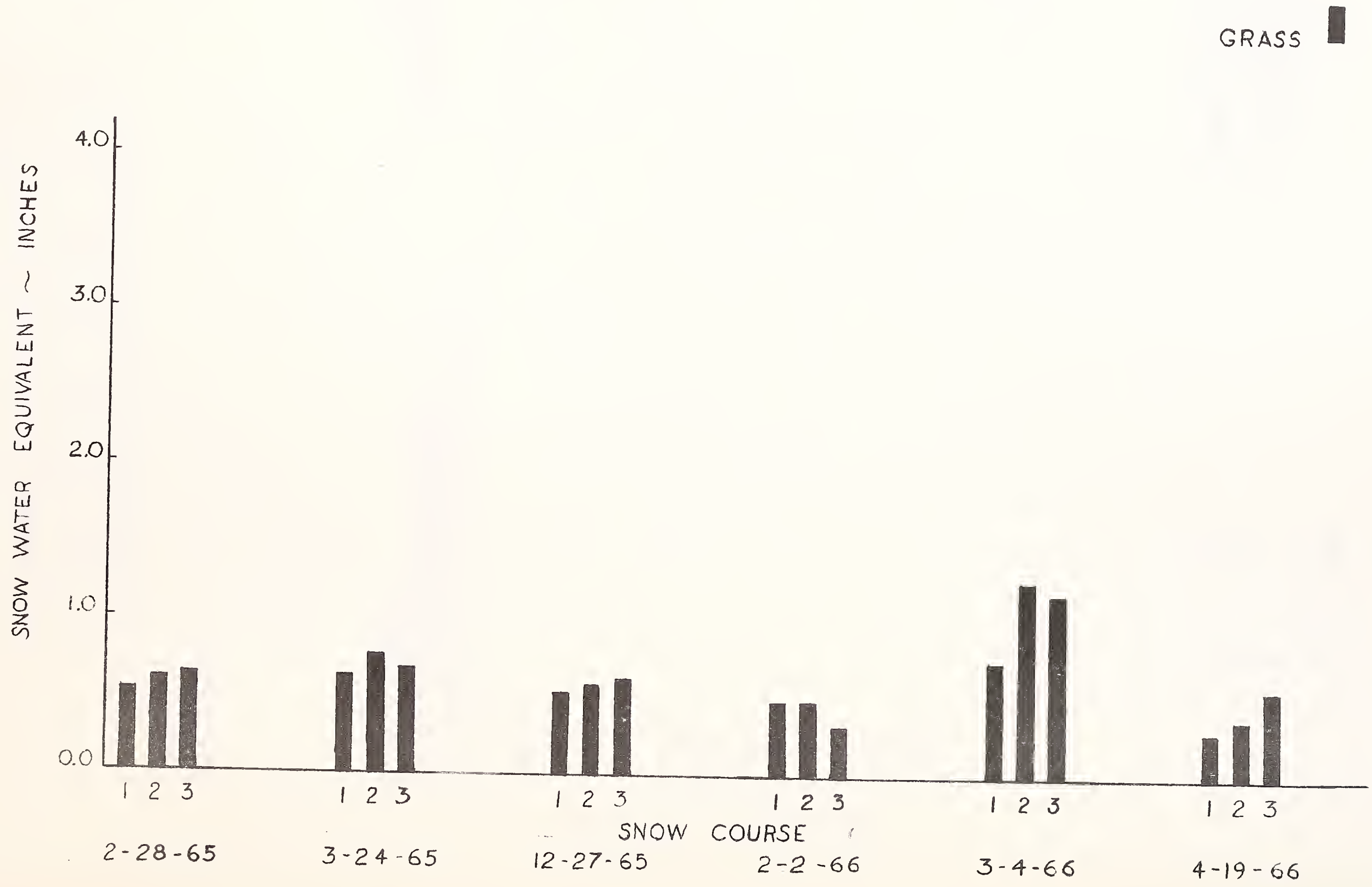
BACON CREEK
SNOW SURVEY DATA



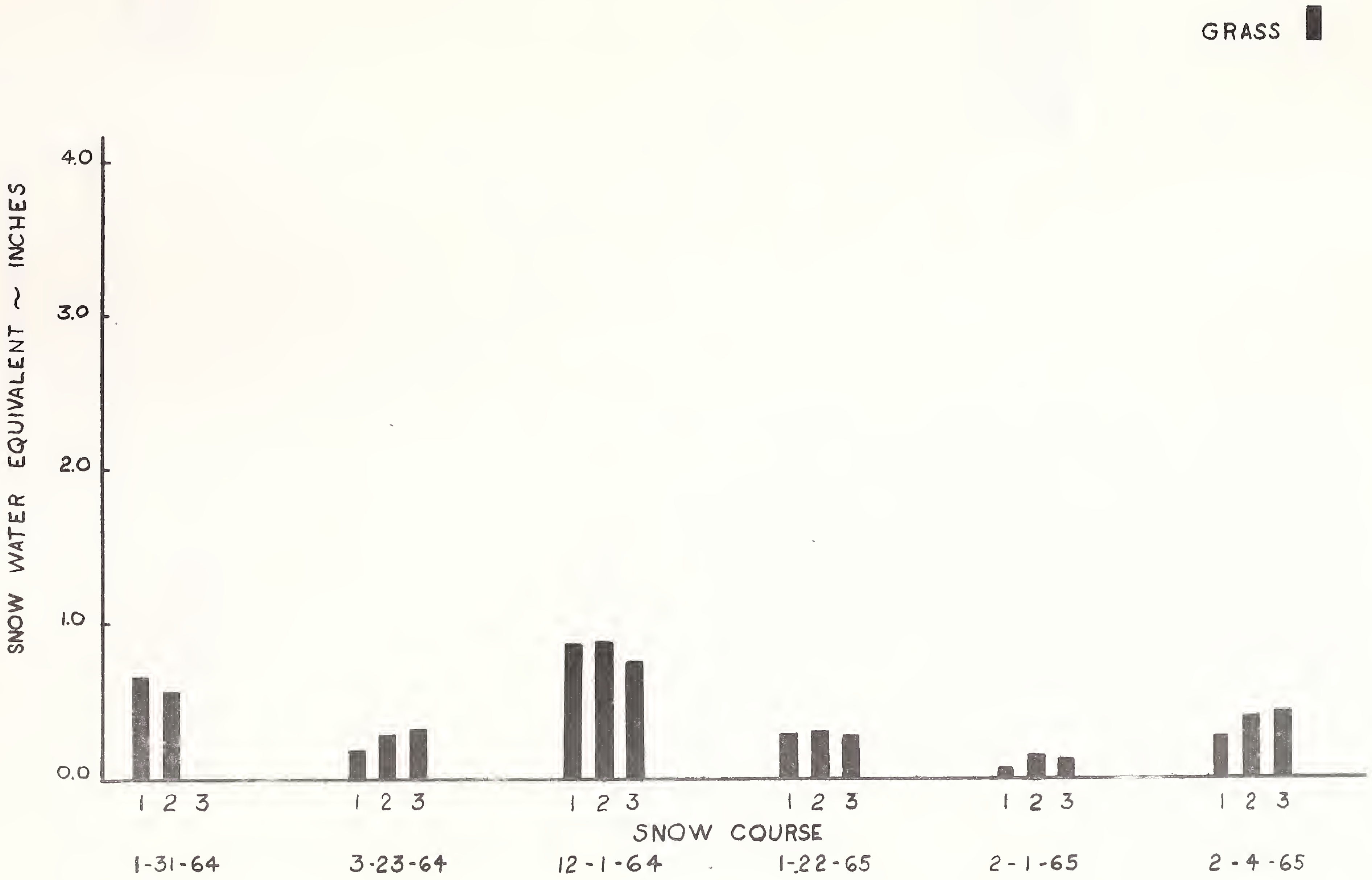
DUCK CREEK
SNOW SURVEY DATA



HUMP CREEK
SNOW SURVEY DATA

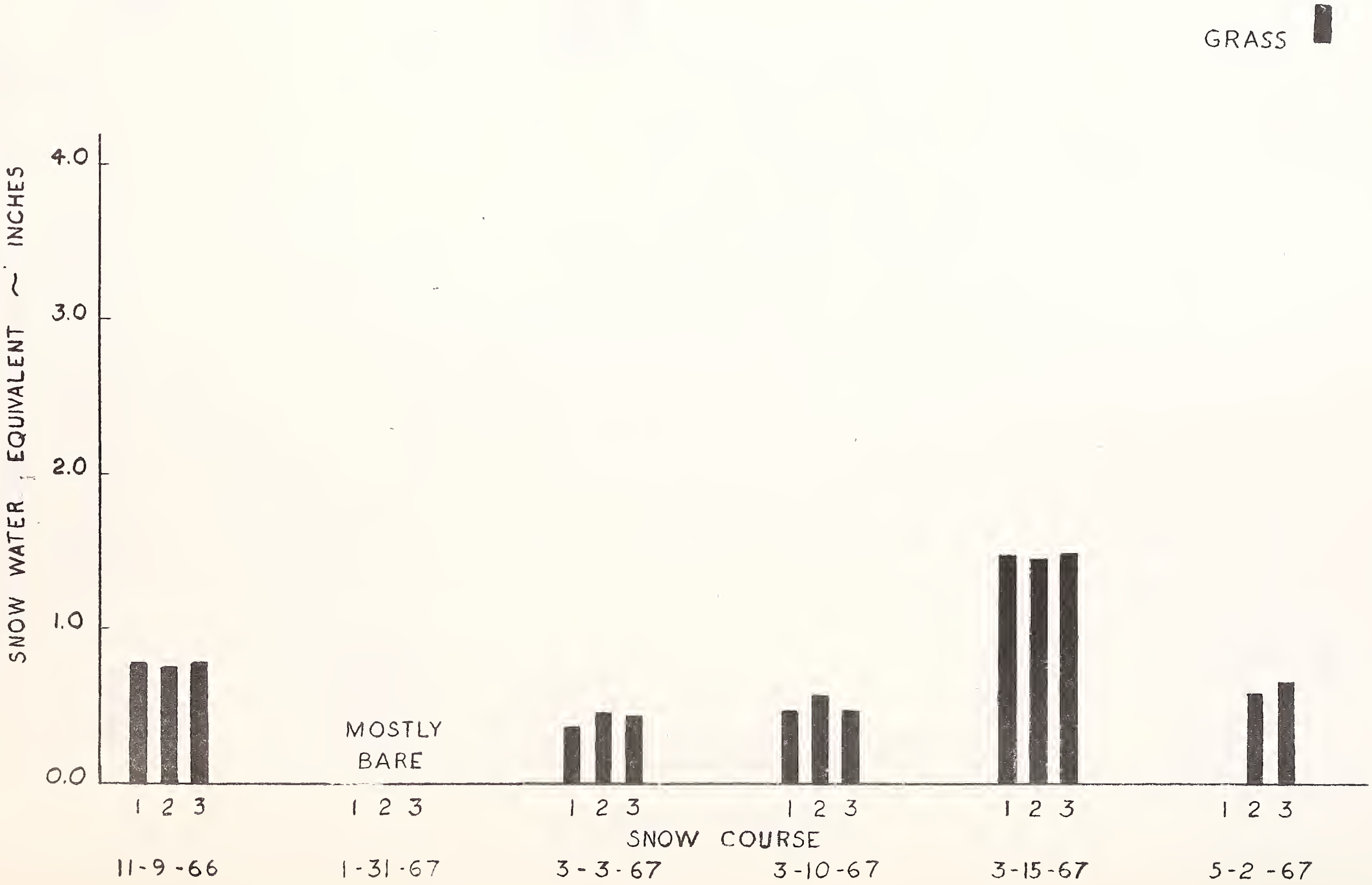


HUMP CREEK
SNOW SURVEY DATA



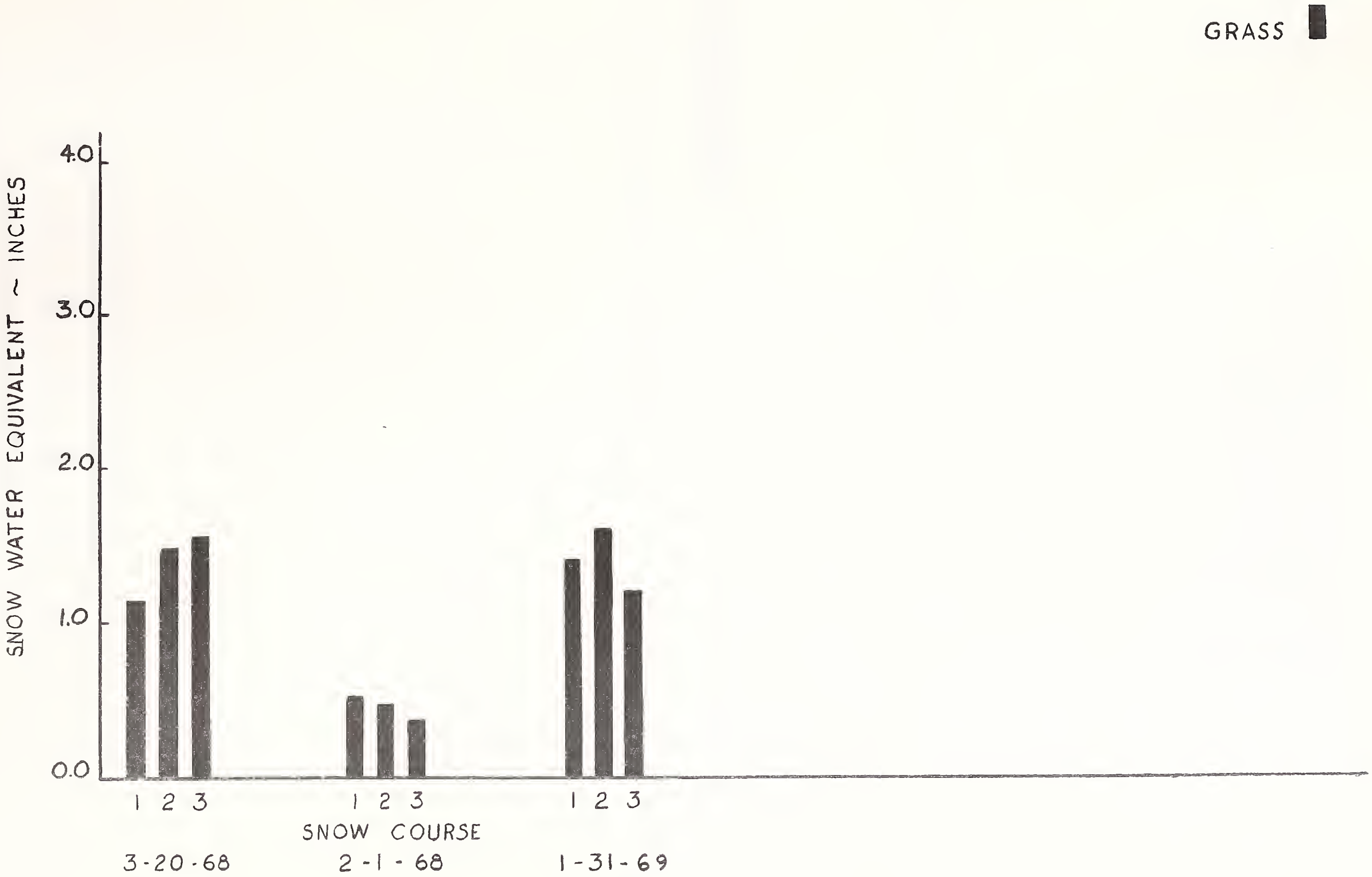
HUMP CREEK

SNOW SURVEY DATA

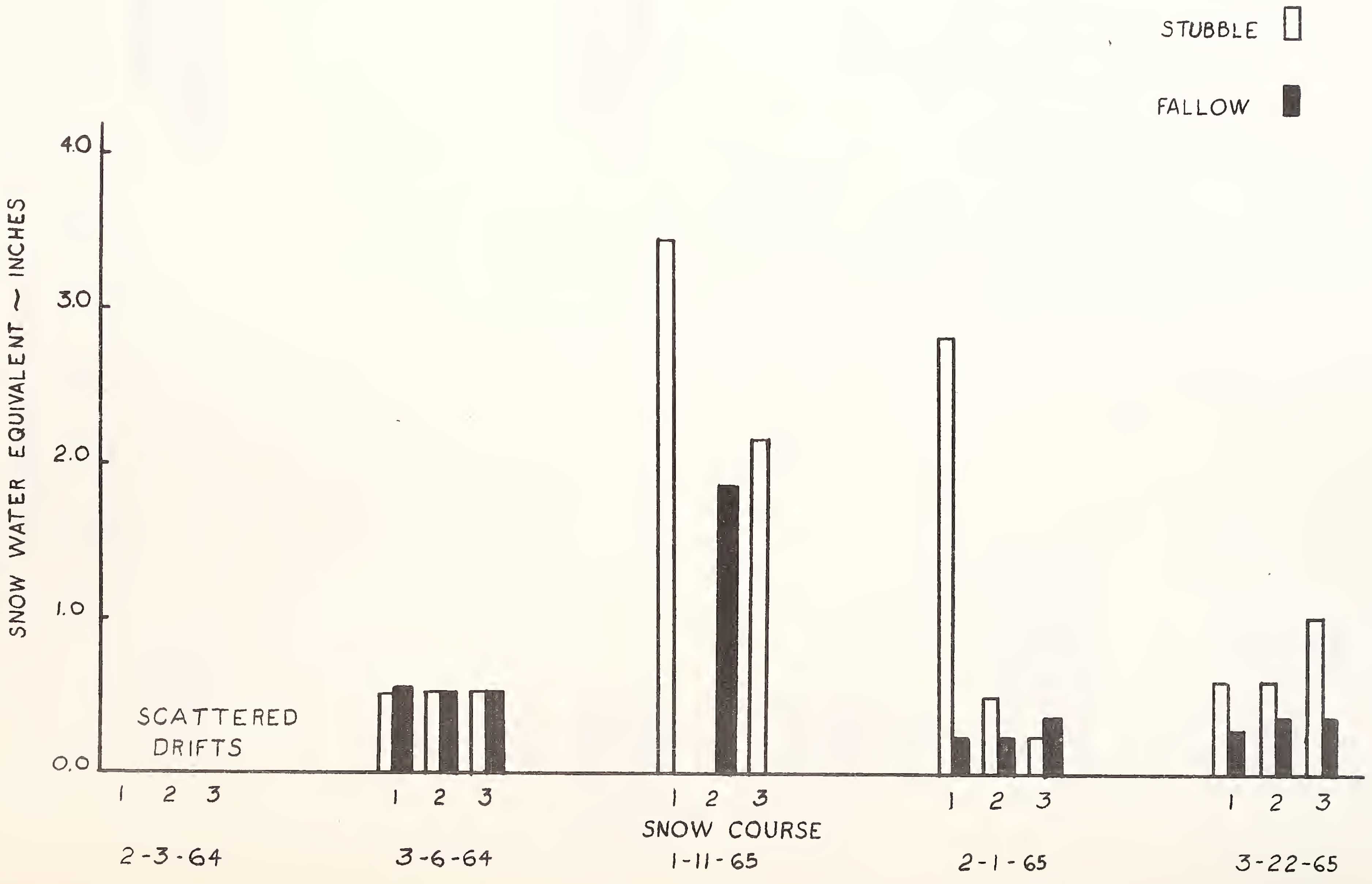


HUMP CREEK

SNOW SURVEY DATA

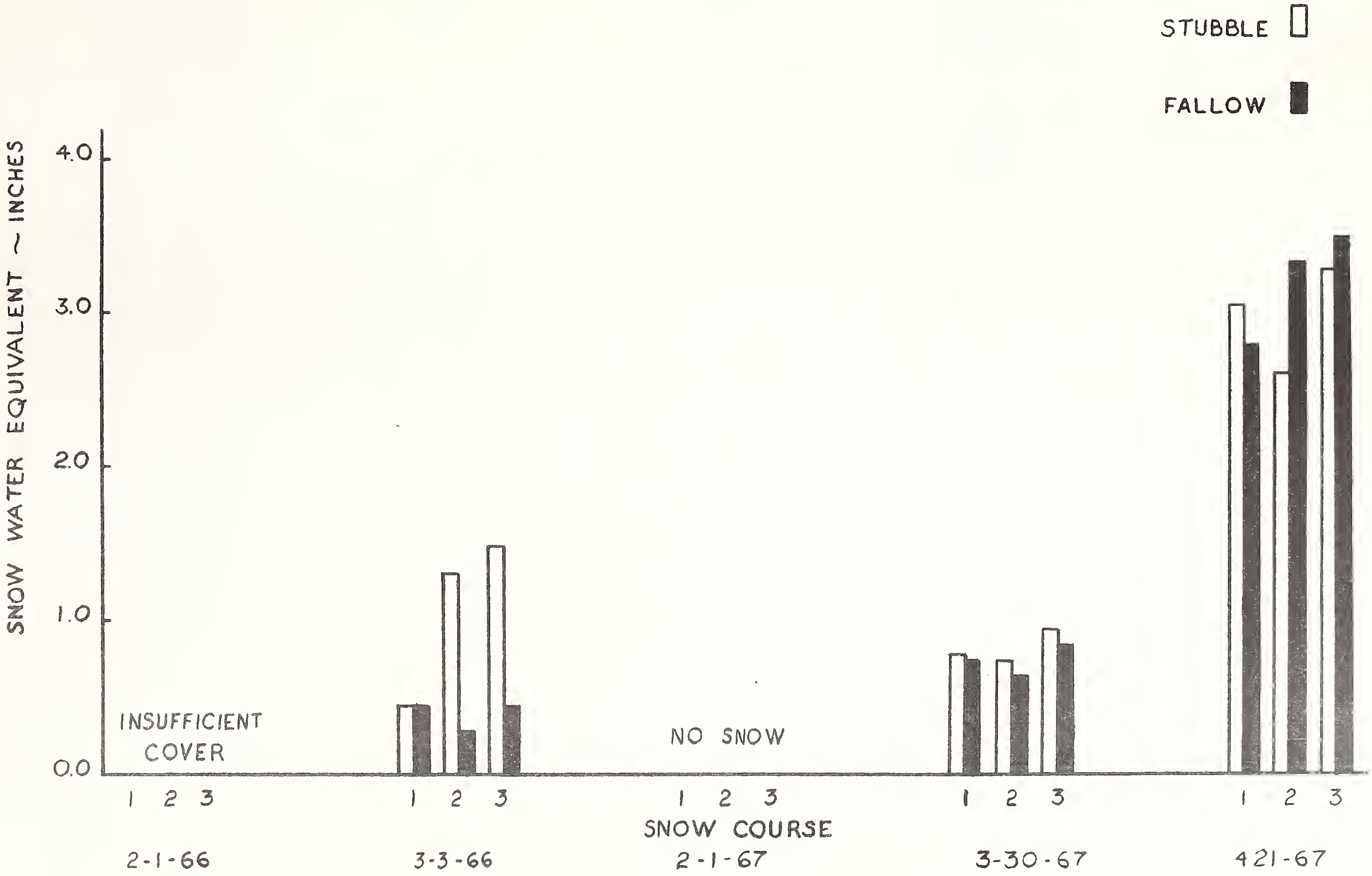


LONE MAN COULEE
SNOW SURVEY DATA

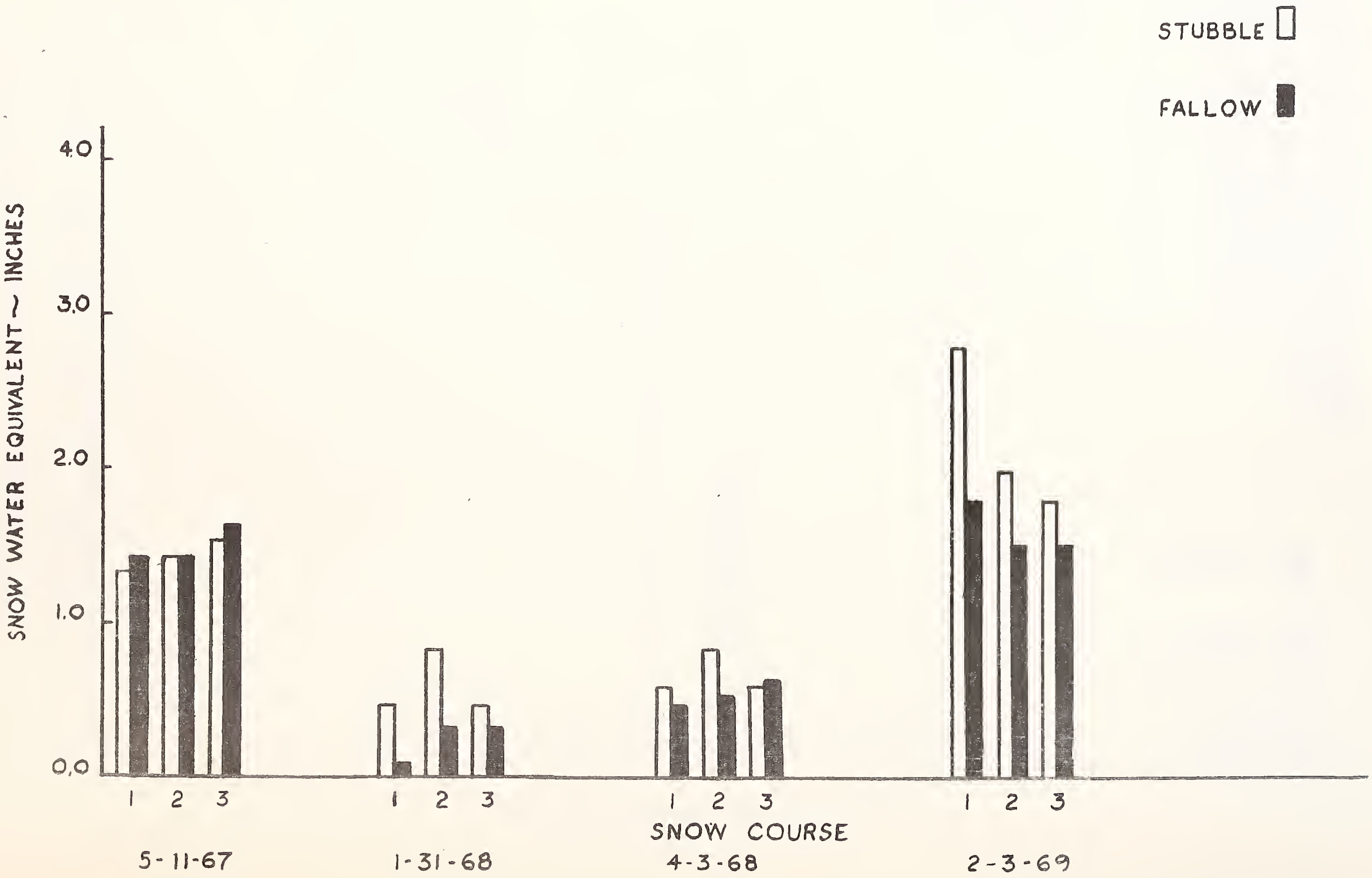


LONE MAN COULEE

SNOW SURVEY DATA



LONE MAN COULEE
SNOW SURVEY DATA



APPENDIX F

VARIABLES FOR MULTIVARIATE STATISTICAL STUDIES

a. Description
b. Values

APPENDIX F

Descriptions of Watershed Parameters and Storm Variables Used in Multi-Variate Statistical Studies

WATERSHED PARAMETERS

1. A : Area of watershed (sq mi).

2. SHP : Shape of watershed (dimensionless) from the ratio of the length of the longest line that could be passed through the center-of-area of the watershed to the length of a perpendicular through this point. Center-of-area found from the balance point of a cut-out of the watershed from SCS soil map.

3. AZ : Azimuth of main channel (deg) measured clock-wise from true North when referred to the water-stage recorder. Mean azimuth of straightline sections of main channel computed from

$$AZ = \frac{\sum (AF_i \ L_i)}{\sum L_i}$$

where

AZ_i = azimuth of each straight-line segment, starting at gaging station and ending at closest point on basin divide to end of main channel on SCS soil map

L_i = length of each straight line segment.

4. ELEV: Elevation of watershed (ft) computed from an average of the elevations at 0.2 and 0.8 of the main channel straight-line-segment length from the gaging station to the nearest point of basin divide from head of main channel.

5. GNDS: Maximum ground slope (ft/ft) computed by dividing the distance from the head of the blue, main-channel line on USGS Quadrangle map to the nearest point on the basin divide, by the change in elevation between these points.

6. GNDL: Overland distance (mi) of flow obtained from distance from head of blue, main-channel line on USGS Quadrangle map to nearest point on basin divide.

7. FREQ: Stream frequency 1/sq mi), or number of stream segments per unit area. Obtained by dividing the total number of stream segments of all orders by the area of the watershed.

8. S : Main channel slope (ft/ft) computed as the slope of a straight line drawn through the main channel straight-line -segment profile. The straight line is fitted to the profile in such a way as to give the same area under the line as the total area under the profile, using equal base lengths.

9. L : Main channel meander length (mi), including distance from end of blue line to nearest point on basin divide.

10. USE : Land use ratio (dimensionless) obtained from a ratio of the vegetated (including forests for Hump Creek) area to the bare-cultivated (summer fallow) area. Relative areas were determined subjectively from each section in the aerial photographs.

11. INFR: Infiltration rate (in./hr) of water shed, weighted for rates different soil types. Computed from

$$\mathrm{INFR} = \frac{\sum (I_i \; A_i)}{\sum A_i}$$

where

I_i = average measured infiltration rate on each soil type of watershed. If not measured, soil was classified by SCS method (type A, B, C, or D), and the average of all watersheds was applied to any soil types which were not tested

A_i = area of each soil type on watershed from planimeter of SCS soil map.

12. POND: Distance-weighted per cent of total area in ponds and reservoirs (%) computed from

$$\text{POND} = \frac{\sum (L_i \; AP_i)}{A \sum L_i} (100)$$

where

L_i = straight-line-segment distance along main channel from gaging station to each pond on SCS soil map

AP_i = full surface area of each pond or reservoir

A = area of watershed.

STORM VARIABLES

13. I : Intensity of precipitation (in./hr) computed as mean of all hourly intensities from all recording precipitation stations from beginning of storm on the first recording station to hour of last runoff from hydrograph.

14. ISD : Standard deviation of precipitation intenstles used in variable 13, computed from

$$(\text{ISD})^2 = \frac{1}{n-1}\left[\sum I_i{}^2 - \frac{(\sum I_i)^2}{n}\right]$$

where

n = total number of hourly intensities recorded for all recording precipitation stations.

15. D : Duration of storm (hr) computed as an average time to the center of area of rainfall hyetographs for all recording precipitation stations, computed from,

$$D = \frac{\sum (DCA_i \; A_i)}{\sum A_i}$$

$$DCA_i = \frac{\sum (I_i \; T_i)}{\sum I_i}$$

Where

DCA_i = time in hours from beginning of each rainfall hyetograph to the center of area of each hyetograph, where hyetograph ends with last precipitation before hour of end of runoff

A_i = Thiessen area of each recording precipitation station.

T_i = time in hours from beginning of hyetograph to I_i, where

I_i = hourly precipitation at the respective recording station.

16. TDF : Time distribution factor (hr) of precipitation over watershed, computed as,

$$TDF - D1 - D$$

where

$$D1 = \frac{\sum (DCA_j \ A_j)}{A_j}$$

and

DCA_j = time in hours from beginning of first appearing rainfall hyetograph to the center of area of each hyetograph

A_j = Thiessen area of each recording precipitation station.

17. TPCP: Total precipitation (in.) computed as an average Thiessen-weighted precipitation from all precipitation stations,

$$TPCP = \frac{\sum (A_i \ P_i)}{\sum A_i}$$

where

P_i = total storm precipitation at each recording and non-recording precipitation station from beginning of storm to end of runoff

A_i = Thiessen area of each station from planimeter of SCS soil map.

18. API : Fourteen-day antecedent precipitation index (in.) computed from

$$API_i = k\ (API_{i-1}) + (P_i)$$

where

API_i = antecedent precipitation index for the ith day after the fourteenth day before the first day of the storm

k = 0.78, a reduction constant to indicate the evaporation-transpiration losses from day to day. (Usually ranges from 0.80 to 0.95 (Chow, p. 25-102), and small value used here for relatively dry watersheds.)

P_i = Thiessen-weighted average daily precipitation for each station

API_{14} = API for first day of storm.

19. SOLM: Average water content (%) of soil for all stations for 3, 9, and 18-inch depths, at beginning of first hyetograph.

20. WDIR: Predominant wind direction during storm period (dimensionless), obtained from weather station data, and given the numbers 1, 2, 3, ..., 8 to represent a wind from the N, NW, W, SW, S, SE, E, NE, respectively.

21. WEEK: Week of the year (dimensionless) in which the date of the peak discharge rate fell. Weeks were numbered from the first week in Jan.

22. AIRT: Average Thiessen-weighted air temperature (deg F), 4 ft above ground, during storm period. Given by

$$\text{AIRT} = \frac{\sum (T_i \; A_i)}{\sum A_i}$$

where

T_i = mean hourly temperature at a station during the time from beginning of first precipitation to end of runoff hydrograph

A_i = Theissen area of each weather station on the watershed

23. ATSD: Average Thiessen-weighted standard deviation of air temperatures (deg F), during the storm period. Given by

$$ST_i^2 = \frac{1}{n-1}\left[\sum T_i^2 - \frac{(\sum T_i)^2}{n}\right]$$

$$ATSD = \frac{\sum (ST_i \ A_i)}{\sum A_i}$$

where

ST_i = standard deviation of hourly air temperatures at a weather station during the storm period

n = number of hourly air temperatures considered

T_i = hourly air temperature at 4 ft above ground at a station

A_i = Thiessen area of each weather station on the watershed.

24. WVEL: Mean wind velocity (mph) during the storm period.

25. WVSD: Standard deviation (mph) of hourly wind velocities during the storm period.

26. SOLT: Average Thiessen-weighted soil temperature (degF), 3 in. below surface, during storm period. Computed exactly as air temperature mean, only using four readings per day at 6-hr intervals, beginning at 3:00 a.m.

27. STSD: Average Thiessen-weighted standard deviation of soil temperatures (deg F), 3 in. below surface, during storm period. Computed in the same manner as the air temperature standard deviation.

28. DEGD: Average Thiessen-weighted Degree-Days (deg F) for a 14-day period prior to the beginning of runoff. Degree-Days for each day was maximum daily temperature, and 14-day average was

$$DEGD = \frac{\sum (DD_i \ A_i)}{14 \sum A_i}$$

where

DD_i = total Degree-Days for a weather station for a 14-day period before the first day of runoff

A_i = Thiessen area of each weather station on the watershed.

29. SWEQ: Snow-water equivalent (in.), or the volume of water in the snow pack on the watershed on the date of the beginning of runoff. Computed from Thiessen-weighted volume from each snow course.

Loss or gain in volume from date of snow survey to date of runoff was computed as the difference between accumulated precipitation and accumulated runoff. This was added to the Thiessen-weighted volume on the watershed at the time of the last snow survey, giving the volume on the date of beginning of runoff.

Thiessen areas of snow courses were used to give the volume on the data of the survey,

$$V = \frac{\sum (VC_i \, A_i)}{\sum A_i}$$

where

VC_i = snow-water equivalent at a snow course,

A_i = Thiessen area of each snow course on the watershed.

VALUES OF VARIABLES USED IN MULTI-VARIATE STUDIES

WATERSHED PARAMETERS

		Bacon Creek	Duck Creek	E. Duck Creek	Hump Creek	Lone Man Coulee
A :	Area (sq. mi.)	17.97	53.79	13.67	7.61	14.10
SHP :	Shape (dimensionless)	4.332	2.721	3.684	2.569	2.448
AZ :	Azimuth (degrees)	289	164	138	177	258
ELEV:	Elevation (feet)	4578	2853	2862	4144	3916
GNDS:	Max. Ground Slope (ft/ft)	.0162	.0596	.0763	.0650	.0194
GNDL:	Overland Distance (miles)	.516	.820	.380	.239	.878
FREQ:	Stream Frequency (1/sq.mi.)	26.66	14.05	15.80	24.18	5.46
S :	Main Channel Slope (ft/ft)	.01182	.00596	.00692	.02412	.00639
L :	Main Channel Meander Length (mi)	12.895	23.614	13.051	6.444	8.446
USE :	Land Use Ratio (dimensionless)	75.18	9.67	10.51	45.64	1.35
INFR:	Infiltration Rate (in./hr.)	.08824	.10022	.09689	.10155	.09481
POND:	Percent Ponds & Reservoirs (%)	.00915	.00614	.02887	.00000	.02342

VALUES OF VARIABLES USED IN MULTI-VARIATE STUDIES

STORM PARAMETERS: BACON CREEK

Peak Discharge Date	QMAX: Peak Discharge (cfs)	RUNF: Total Runoff (in.)	I : Mean Intensity (in/hr)	ISD : Std Dev Int. (in/hr)	D : Duration (hr)	TDF : Time Duration Factor (hr)	TPCP: Total Precip. (in.)	API : Ant. Prec. Index (in.)	SOLM: Soil Moisture Content (%)	WDIR: Direction Storm Movement	WEEK: Week of the Year	AIRT: Air Temp. during Storm (degrees)	ATSD: Std Dev Air Temp (deg.)	WVEL: Wind Velocity (mi/hr)	WVSD: Std Dev Wind Vel (mi/hr)	SOLT: Soil Temperature (deg)	STSD: Std Dev Soil Temp (deg)	DEGD: Degree-days (degrees)	SWEQ: Snow-Water Equivalent (in)
6/ 8/64	86	.0381	.1388	.1156	29.1	16.0	3.0810	.4431	19	2	24	56.67	13.198	11.36	7.067	61.45	7.924	32.84	0.00
6/12/65	920	.1198	.2761	.2192	10.1	0.0	1.6673	.0200	17	6	24	56.69	8.848	13.76	7.488	58.84	6.679	39.43	0.00
7/30/65	76	.0104	.2071	.2720	4.9	2.4	.6824	.0231	14	1	31	66.68	5.445	6.82	11.583	70.69	3.800	48.00	0.00
6/13/67	59	.0212	.0526	.0505	16.8	9.5	1.1539	1.0460	18	5	24	53.35	8.714	12.32	7.617	56.69	6.868	36.37	0.00

STORM PARAMETERS: DUCK CREEK

Peak Discharge Date	QMAX: Peak Discharge (cfs)	RUNF: Total Runoff (in.)	I : Mean Intensity (in/hr)	ISD : Std Dev Int. (in/hr)	D : Duration (hr)	TDF : Time Duration Factor (hr)	TPCP: Total Precip. (in.)	API : Ant. Prec. Index (in.)	SOLM: Soil Moisture Content (%)	WDIR: Direction Storm Movement	WEEK: Week of the Year	AIRT: Air Temp. during Storm (degrees)	ATSD: Std Dev Air Temp (deg.)	WVEL: Wind Velocity (mi/hr)	WVSD: Std Dev Wind Vel (mi/hr)	SOLT: Soil Temperature (deg)	STSD: Std Dev Soil Temp (deg)	DEGD: Degree-days (degrees)	SWEQ: Snow-Water Equivalent (in)
6/20/64	23	.0362	.1373	.1240	13.8	0.9	2.3483	.1773	13	8	25	64.85	9.713	10.38	6.131	66.35	4.952	38.57	0.00
7/ 6/64	78	.0483	.3250	.3975	3.9	2.3	1.3895	.8389	11	8	28	71.13	8.960	7.92	5.116	72.78	4.880	45.91	0.00
5/ 8/65	18	.0240	.0438	.0315	41.1	2.6	1.9383	.3306	16	6	19	40.01	18.441	10.82	8.742	33.65	12.006	29.01	0.23
6/16/65	342	.3475	.1053	.1397	45.3	3.4	3.7169	.2252	12	5	25	64.11	8.600	11.41	6.405	67.24	5.066	41.52	0.00
6/30/65	26	.0148	.1571	.2179	13.0	2.7	.5988	.1556	12	6	27	61.89	8.209	8.48	5.998	68.11	6.078	42.85	0.00
7/ 6/65	61	.0472	.0728	.1467	13.9	8.2	.4225	.2343	12	4	28	41.91	5.076	6.32	5.175	70.28	4.928	43.18	0.00
7/13/65	150	.1534	.0766	.1020	11.6	0.4	.9652	.5922	10	5	29	43.97	5.893	5.03	4.038	72.90	6.092	45.34	0.00
3/13/66	42	.0564	.0138	.0065	226.1	5.6	.3225	.1656	13	5	12	6.63	5.150	13.38	5.180	23.84	5.139	2.76	0.59
7/ 1/66	170	.0837	.1181	.2391	6.7	0.7	1.4983	.4836	12	2	26	67.00	15.129	7.10	5.698	73.28	5.192	51.46	0.00
5/12/67	6	.0108	.0431	.0652	24.0	1.8	1.2247	.5177	13	6	19	42.17	11.129	10.41	6.523	43.94	5.369	14.78	0.00

VALUES OF VARIABLES USED IN MULTI-VARIATE STUDIES

STORM PARAMETERS: E. FORK DUCK CREEK

Peak Discharge Date	QMAX: Peak Discharge (cfs)	RUNF: Total Runoff (in.)	I : Mean Intensity (in/hr)	ISD : Std Dev Int. (in/hr)	D : Duration (hr)	TDF : Time Duration Factor (hr)	TPCP: Total Precip. (in)	API : Ant. Prec. Index (in.)	SOLM: Soil Moisture Content (%)	WDIR: Direction Storm Movement	WEEK: Week of the Year	AIRT: Air Temp. during Storm (degrees)	ATSD: Std Dev Air Temp (deg.)	WVEL: Wind Velocity (mi/hr)	WVSD: Std Dev Wind Vel (mi/hr)	SOLT: Soil Temperature (deg)	STSD: Std Dev Soil Temp (deg)	DEGD: Degree-Days (degrees)	SWEQ: Snow-Water Equivalent (in)
6/19/64	45	.0600	.1496	.1210	14.1	0.6	2.2966	.5828	13	8	25	67.58	9.606	9.48	6.031	67.53	4.990	39.23	0.00
7/ 5/64	84	.1840	.2900	.3622	4.8	0.0	1.4341	.9819	11	8	28	70.98	9.298	7.69	4.799	72.56	5.375	46.78	0.00
3/30/65	72	.4126	.0173	.0121	112.7	0.0	.3671	.0324	9	7	14	23.75	17.654	10.09	6.719	25.57	7.237	-20.83	1.00
5/ 8/65	10	.0382	.0414	.0331	40.4	0.0	1.3805	.4846	16	6	19	39.76	19.033	10.85	9.054	39.74	14.924	28.02	0.97
6/16/65	205	.3221	.1223	.1469	36.8	1.8	3.6523	.5536	12	5	25	61.58	7.300	14.02	7.046	65.01	4.547	41.67	0.00
7/ 5/65	16	.0065	.0966	.1032	1.5	1.3	.4246	.3364	12	4	28	59.07	4.584	6.20	6.858	70.27	6.526	42.95	0.00
7/12/65	100	.1741	.1015	.1241	9.1	0.7	.9599	.6950	10	5	29	64.00	9.287	5.85	4.225	68.59	5.335	45.15	0.00
8/ 6/65	10	.0056	.1385	.1521	5.4	0.6	1.4998	.3192	6	2	32	60.21	1.842	10.17	4.697	72.62	5.423	51.58	0.00
8/29/65	18	.0126	.1092	.3025	39.6	16.8	.7394	.6007	25	6	36	54.18	9.695	7.39	10.093	62.07	5.583	45.22	0.00
3/10/66	65	.3556	.0141	.0069	248.8	4.2	.4649	.1157	13	5	11	19.22	21.113	13.43	4.317	22.18	4.480	-4.35	0.89
7/ 1/66	198	.2178	.1472	.2893	5.8	0.7	1.5503	1.2252	12	2	26	61.98	17.453	6.57	6.011	72.41	4.501	51.40	0.00
3/10/67	32	.0338	.0143	.0058	7.0	0.7	.1469	.0294	8	4	10	22.37	7.624	8.62	6.466	29.19	1.853	4.71	0.20
3/22/67	27	.0795	.0134	.0100	39.9	0.6	.0907	.0512	8	4	12	37.18	10.829	11.07	5.593	34.33	5.530	5.65	0.22

STORM PARAMETERS: HUMP CREEK

Peak Discharge Date	QMAX: Peak Discharge (cfs)	RUNF: Total Runoff (in.)	I : Mean Intensity (in/hr)	ISD : Std Dev Int. (in/hr)	D : Duration (hr)	TDF : Time Duration Factor (hr)	TPCP: Total Precip. (in)	API : Ant. Prec. Index (in.)	SOLM: Soil Moisture Content (%)	WDIR: Direction Storm Movement	WEEK: Week of the Year	AIRT: Air Temp. during Storm (degrees)	ATSD: Std Dev Air Temp (deg.)	WVEL: Wind Velocity (mi/hr)	WVSD: Std Dev Wind Vel (mi/hr)	SOLT: Soil Temperature (deg)	STSD: Std Dev Soil Temp (deg)	DEGD: Degree-Days (degrees)	SWEQ: Snow-Water Equivalent (in)
3/24/67	8	.0166	.0410	.0308	13.4	0.0	.8251	.1735	20	1	12	15.63	11.698	4.14	4.217	29.72	1.092	9.38	1.58
6/14/67	84	1.2141	.0551	.0485	97.2	6.9	7.4529	1.4432	22	5	24	60.63	8.353	9.14	6.052	62.72	4.001	34.45	0.00
7/14/67	9	.0066	.1600	.1508	2.1	2.4	.4930	.1249	20	4	28	64.21	7.539	7.10	4.859	65.32	3.078	46.16	0.00

VALUES OF VARIABLES USED IN MULTI-VARIATE STUDIES

STORM PARAMETERS: LONE MAN COULEE

Peak Discharge Date	QMAX: Peak Discharge (cfs)	RUNF: Total Runoff (in.)	I : Mean Intensity (in/hr)	ISD : Std Dev Int. (in/hr)	D : Duration (hr)	TDF : Time Duration Factor (hr)	TPCP: Total Precip. (in.)	API : Ant. Prec. Index (in.)	SOLM: Soil Moisture Content (%)	WDIR: Direction Storm Movement	WEEK: Week of the Year	AIRT: Air Temp. during Storm (degrees)	ATSD: Std Dev Air Temp (deg.)	WVEL: Wind Velocity (mi/hr)	WVSD: Std Dev Wind Vel (mi/hr)	SOLT: Soil Temperature (deg)	STSD: Std Dev Soil Temp (deg)	DEGD: Degree-days (degrees)	SWEQ: Snow-Water Equivalent (in)
3/30/64	55	.0211	.0154	.0083	57.5	0.4	.3732	.0755	17	3	14	25.43	13.379	10.53	6.718	29.02	2.768	0.23	0.89
5/ 3/64	195	.4738	.0729	.0544	29.2	0.4	5.4935	.6826	18	3	19	46.06	9.741	13.87	8.323	44.54	3.634	13.00	0.00
6/ 8/64	1720	1.8063	.1323	.1196	39.1	0.0	5.7759	.0916	14	2	24	54.38	8.760	12.20	6.789	55.86	3.805	32.08	0.00
2/17/65	390	.5353	.0168	.0085	27.7	0.0	.1432	.0875	14	3	8	35.03	13.834	24.69	11.800	30.08	1.960	1.23	0.70
2/27/65	29	.0102	.0160	.0081	51.4	0.0	.1529	.0105	14	3	9	23.32	18.744	18.46	10.096	29.38	2.875	4.74	0.13
4/ 1/65	73	.1242	.0210	.0155	278.2	0.0	.5462	.0478	20	3	14	7.68	14.284	10.10	6.197	25.19	3.903	-17.71	0.56
4/ 6/65	240	.4000	.0313	.0275	33.4	1.2	.3218	.1974	15	5	15	33.54	5.776	8.21	4.545	32.41	2.055	-12.52	0.60
4/12/65	18	.0363	.0306	.0391	4.8	35.0	.1716	.1519	20	4	16	44.28	10.256	13.51	8.095	37.28	3.329	-2.71	0.25
4/17/65	32	.0226	.0219	.0129	38.5	9.8	.3013	.2062	20	2	16	36.40	9.318	12.14	7.602	36.52	3.736	8.49	0.51
6/17/65	112	.1696	.1078	.1013	16.7	0.0	2.8517	.8946	15	2	25	54.69	4.294	17.01	6.503	55.53	2.138	28.46	0.00
6/25/65	200	.3377	.0469	.0780	19.7	1.1	1.3531	.5834	19	2	26	53.18	4.297	17.18	8.042	56.79	3.468	33.02	0.00
7/12/65	44	.0450	.0589	.0435	4.8	3.6	.7725	.0765	16	4	29	58.69	10.236	4.59	3.933	60.76	3.534	36.23	0.00
2/23/66	20	.0974	.0166	.0136	300.8	1.3	.4792	.0240	15	3	9	17.24	17.617	10.03	8.936	24.34	3.191	-5.28	0.11
3/ 9/66	150	.1229	.0117	.0038	11.0	9.8	.0997	.0265	15	4	11	32.13	8.639	11.54	8.216	28.64	1.233	6.97	0.27
7/14/66	53	.0167	.3550	.4236	1.1	0.4	.7898	.0564	17	3	28	67.27	10.239	8.44	6.201	64.36	3.405	37.33	0.00
2/28/67	13	.0077	.0189	.0142	376.1	24.4	.2158	.0116	18	3	9	27.32	12.697	13.61	9.674	28.88	1.776	3.93	0.09
5/ 7/67	111	.2644	.0253	.0175	57.3	16.6	.5429	.1763	14	4	19	36.02	11.179	11.32	6.703	34.95	3.000	1.50	1.09
5/14/67	49	.1289	.0251	.0209	30.7	1.2	.5222	.3835	14	2	20	42.39	9.370	12.38	7.422	33.60	2.558	6.57	1.37
5/30/67	18	.0316	.0412	.0256	14.9	0.8	.7582	.1856	12	7	22	55.48	8.903	12.29	7.106	56.55	3.059	33.05	0.00
6/10/67	143	.1967	.0560	.0949	35.2	0.0	1.9205	.7387	13	2	23	48.06	6.898	14.60	6.646	50.86	2.592	31.50	0.00

APPENDIX G

COMPARISON OF STOCHASTIC PEAK FLOW METHODS

STATISTICAL ANALYSIS OF SEVEN STOCHASTIC METHODS:

Bacon Creek Watershed
Duck Creek Watershed
East Fork Duck Creek Watershed
Hump Creek Watershed
Lone Man Coulee Watershed

STATISTICAL ANALYSIS OF SEVEN STOCHASTIC METHODS: BACON CREEK WATERSHED

t_R	1.08 yr	1.17 yr	1.27 yr	1.40 yr	1.56 yr	1.75 yr	2.00 yr	2.33 yr	2.80 yr	3.50 yr	4.67 yr	7.00 yr	14.0 yr
Actual Data	20.00	25.00	25.00	35.00	50.00	80.00	95.00	125.00	130.00	190.00	820.00	922.00	3230.00
Gumbel	-876.50	-604.56	-396.02	-211.52	-36.44	137.51	316.73	507.73	718.64	961.78	1259.03	1658.47	2312.15
Gringorten #1	-862.16	-508.03	-262.26	-61.26	116.65	282.19	442.08	601.97	767.50	945.41	1146.41	1392.18	1746.31
Gringorten #2	-781.27	-485.14	-271.95	-92.32	71.03	227.06	381.81	540.55	709.07	895.31	1112.51	1388.39	1806.54
Gringorten #3	-728.48	-465.94	-272.06	-105.48	48.60	198.07	348.52	505.14	673.92	863.39	1088.20	1379.48	1832.60
Gringorten #4	-700.27	-454.35	-270.32	-110.62	38.37	184.04	331.78	486.71	654.93	845.31	1073.18	1371.50	1841.93
Robinson	195.12	268.29	329.27	378.05	432.93	487.81	542.69	597.57	658.43	731.71	823.18	945.13	1128.06
Log-Pearson	4.00	8.90	14.50	24.00	36.00	52.00	78.00	110.00	160.00	245.00	470.00	740.00	1600.00

DUCK CREEK WATERSHED

t_R	1.08 yr	1.18 yr	1.30 yr	1.44 yr	1.63 yr	1.86 yr	2.17 yr	2.60 yr	3.25 yr	4.33 yr	6.50 yr	13.0 yr
Actual Data	1.00	10.00	40.00	50.00	50.00	130.00	270.00	340.00	520.00	640.00	890.00	1000.00
Gumbel	-194.13	-80.24	8.02	86.97	162.85	239.39	319.77	407.61	508.06	630.11	793.30	1059.29
Gringorten #1	-178.60	-34.18	66.77	149.98	224.28	294.18	362.66	432.55	506.86	590.06	691.01	835.43
Gringorten #2	-148.78	-27.47	60.62	135.53	204.38	271.00	338.15	408.53	485.55	574.66	687.10	856.53
Gringorten #3	-129.13	-21.22	59.21	129.01	194.30	258.52	324.29	394.33	472.25	564.04	682.28	865.29
Gringorten #4	-118.56	-17.31	59.19	126.26	189.58	252.36	317.19	386.78	464.85	557.66	678.50	868.17
Robinson	179.04	259.90	323.43	392.74	450.50	519.80	560.23	623.76	704.62	785.48	912.54	1085.81
Log-Pearson	0.68	2.40	5.40	10.00	21.00	35.00	59.00	110.00	199.00	420.00	960.00	2400.00

STATISTICAL ANALYSIS OF SEVEN STOCHASTIC METHODS: EAST FORK DUCK CREEK WATERSHED

t_R	1.04 yr	1.15 yr	1.25 yr	1.36 yr	1.50 yr	1.67 yr	1.88 yr	2.14 yr	2.50 yr	3.00 yr	3.75 yr	5.00 yr	7.50 yr	15.0 yr
Actual Data	8.00	10.00	30.00	60.00	93.00	106.00	134.00	140.00	190.00	224.00	250.00	273.00	505.00	650.00
Gumbel	-87.48	-32.83	8.70	45.09	79.27	112.81	146.86	182.46	220.81	263.51	313.04	373.89	456.01	590.85
Gringorten #1	-89.21	-16.34	33.93	74.76	110.64	143.74	175.36	206.50	238.12	271.21	307.09	347.93	398.19	471.06
Gringorten #2	-71.03	-10.34	33.02	69.28	101.97	132.86	163.12	193.65	225.38	259.40	297.30	341.79	398.61	485.15
Gringorten #3	-59.26	-5.62	33.68	67.16	97.84	127.27	156.50	186.41	217.91	252.18	290.93	337.17	397.38	491.44
Gringorten #4	-53.01	-2.84	34.40	66.43	96.02	124.62	153.23	182.70	213.97	248.23	287.26	334.23	396.01	493.82
Robinson	100.73	134.31	161.17	201.46	235.04	255.19	295.48	322.34	352.56	389.49	433.14	483.51	550.66	664.83
Log-Pearson	11.00	18.00	29.00	39.00	53.00	70.00	90.00	110.00	149.00	195.00	250.00	350.00	520.00	980.00

STATISTICAL ANALYSIS OF SEVEN STOCHASTIC METHODS: HUMP CREEK WATERSHED

t_R	1.11 yr	1.25 yr	1.43 yr	1.67 yr	2.00 yr	2.50 yr	3.33 yr	5.00 yr	10.0 yr
Actual Data	0.00	1.00	5.00	8.00	15.00	30.00	87.00	130.00	307.00
Gumbel	-79.71	-40.63	-8.96	20.83	51.29	84.59	123.78	174.96	256.84
Gringorten #1	-65.12	-20.50	11.67	39.14	64.78	90.41	117.88	150.06	194.68
Gringorten #2	-59.13	-20.99	7.75	33.24	57.92	83.49	111.93	146.72	197.82
Gringorten #3	-54.98	-20.63	6.01	30.20	54.12	79.44	108.19	144.21	198.73
Gringorten #4	-52.68	-20.24	5.30	28.76	52.22	77.30	106.09	142.61	198.75
Robinson	40.74	51.78	61.11	71.30	80.64	89.97	102.71	118.83	143.45
Log-Pearson	0.68	2.20	4.80	9.50	17.00	35.00	70.00	150.00	500.00

LONE MAN COULEE WATERSHED

t_R	1.11 yr	1.25 yr	1.43 yr	1.67 yr	2.00 yr	2.50 yr	3.33 yr	5.00 yr	10.0 yr
Actual Data	15.00	22.00	27.00	32.00	39.00	135.00	140.00	400.00	1740.00
Gumbel	-514.74	-298.89	-123.95	40.61	208.82	392.77	609.26	891.92	1344.20
Gringorten #1	-434.16	-187.70	-10.00	141.74	283.33	424.92	576.66	754.37	1000.83
Gringorten #2	-401.09	-190.41	-31.66	109.12	245.43	386.70	543.78	735.94	1018.19
Gringorten #3	-378.14	-188.44	-41.26	92.35	224.49	364.30	523.11	722.08	1023.21
Gringorten #4	-365.43	-186.29	-45.21	84.40	213.95	352.47	511.53	713.26	1023.34
Robinson	80.60	148.31	199.90	251.48	299.84	354.65	415.91	509.41	644.83
Log-Pearson	7.20	17.00	31.00	52.00	84.00	148.00	240.00	400.00	900.00

APPENDIX H

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

Sta. No.	Station Name	Area sq.mi.	Elev ft	Yrs. Rec.	Mean Annual Flood		Mn. Annual Flood		Sample Std.Dev	Pop. Std.Dev. Not over (95%conf)	F	F.05	Pooled with Sta.Nos.	Pooled Mean		Pooled Std.Dev.	
					On Basin	+ or -	Per sqmi	+ or -						On Basin	Per sqmi	On Basin	Per sqmi
1	Long Creek near Lake View	33.9	6800	8	159.12	49.47	4.69	1.46	73.83	116.06							
2	Red Rock River Trib, Monida	1.0	6750	8	5.37	3.22	5.38	3.22	4.81	7.56	8.85	2.85	Cannot Pool Stations				
4	Muddy Creek near Dell	62.7	6570	9	69.56	36.01	1.11	.57	58.09	87.95							
5	Big Sheep Cr below Muddy Cr	280.	6530	17	360.41	76.20	1.29	.27	179.94	235.86							
7	Grasshopper Cr nr Dillon	348.	5350	32	428.59	99.28	1.23	.28	331.15	1190.10			8,9,10	3549.60	10.20	19693.32	56.59
8	Beaverhead R. Trib., Dillon	0.6	5250	7	4.44	4.46	7.16	7.19	6.07	10.00	2.31	2.79	7,9,10	6.32	10.20	35.08	56.59
9	Beaverhead R. Trib. # 2	0.4	4970	8	22.81	39.85	57.03	99.63	59.48	39.85			7,8,10	4.08	10.20	22.64	56.59
10	Idaho Cr near Alder	10.8	5420	9	30.33	17.46	2.81	1.62	28.16	42.63			7,8,9	110.16	10.20	611.17	56.59
11	Moose Creek near Divide	41.4	5430	9	107.00	28.30	2.58	.68	45.69	69.18	4.15	4.45	12	131.65	3.18	54.64	1.32
12	Fish Creek nr Silverstar	39.5	4790	10	147.10	30.00	3.72	.75	51.77	76.08			11	125.61	3.18	52.14	1.32
13	Jefferson Trib. Whitehall	1.8	4340	9	6.56	5.60	3.54	3.03	9.03	13.67			13 - 18	24.12	13.04	60.75	32.84
14	Jefferson Trib # 3	4.5	4400	11	31.73	27.61	7.05	6.13	50.53	72.44			13 - 18	58.68	13.04	149.78	32.84
15	Sand Creek nr Sappington	9.4	4240	9	324.22	425.78	34.46	45.25	686.74	1039.74	1.14	2.42	13 - 18	122.58	13.04	308.70	32.84
16	Jeff'n Trib #3 nr Sappington	1.1	4200	8	21.76	22.94	19.09	20.12	34.24	53.82			13 - 18	14.34	13.04	36.12	32.84
17	Jeff'n Trib #4 nr Three Fks	.5	4140	9	4.50	2.18	8.49	4.12	3.51	5.32			13 - 18	6.91	13.04	17.40	32.84
18	Jeff'n Trib #5 nr Three Fks	3.7	4120	9	28.22	30.50	7.64	8.27	49.20	74.49			13 - 18	48.25	13.04	121.51	32.84
19	Squaw Cr nr Gallatin Gate'y	40.4	5400	10	247.60	83.47	6.13	2.07	144.00	211.61			19 - 23	275.12	6.81	160.39	3.97
20	Logger Cr n Gallatin Gateway	2.5	5340	10	15.20	4.13	6.13	1.67	7.13	10.48			19 - 23	16.89	6.81	9.84	3.97
21	Rocky Creek nr Bozeman	49.0	4980	12	325.92	67.30	6.65	1.37	129.80	182.28	2.14	2.58	19 - 23	333.69	6.81	194.53	3.97
22	Pitcher Creek nr Bozeman	2.3	5040	9	11.67	3.64	5.01	1.56	5.87	8.89			19 - 23	15.87	6.81	9.25	3.97
23	Bear Canyon Cr nr Bozeman	17.0	5183	12	161.08	51.80	49.46	3.05	99.91	140.30			19 - 23	115.77	6.81	67.49	3.97
24	Castle Cr Trib nr Ringling	2.6	5400	9	21.78	6.21	8.41	2.40	10.00	15.15							
25	Cabin Cr near Townsend	12.6	4900	8	17.12	7.31	1.36	.58	10.91	17.15	22.69	3.44	Cannot Pool Stations				
26	Deep Cr b.N.Fk.Deep Cr.	87.7	4510	10	229.20	44.95	2.61	.51	77.55	113.95							
27	Mitchell Gulch, E.Helena	8.1	4060	10	31.00	20.10	3.81	2.48	34.67	50.95	.70	4.45	30	36.57	4.52	30.50	3.75
30	McClellan Cr @ Div.Dam	33.2	4200	9	175.78	65.41	5.29	1.97	105.50	159.73			27	150.06	4.52	125.16	3.75
28	Jackson Cr nr E. Helena	3.4	4990	8	13.62	3.80	31.69	144.59	5.68	8.93			29,31	13.97	4.06	8.70	2.53
29	Crystal Cr nr E. Helena	3.8	4860	8	13.00	5.41	3.45	1.43	8.07	12.69	.49	3.42	28,31	15.31	4.06	9.54	2.53
31	L. Porcupine Cr Trib, Helena	.5	5360	10	2.23	.94	4.64	1.95	1.62	2.37			28,29	1.95	4.06	1.21	2.53
32	Lyons Creek nr Wolf Creek	29.4	3730	10	152.30	87.69	5.18	2.98	151.28	222.30			33,34	248.14	8.44	415.71	14.14
33	Dog Creek near Craig	15.9	3660	9	215.00	224.59	13.52	14.12	362.23	548.43	.89	3.39	32,34	134.20	8.44	224.83	14.14
34	Wegner Creek near Craig	35.0	3450	9	243.89	196.45	6.97	5.61	316.86	479.73			32,33	295.40	8.44	494.90	14.14

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

Sta. No.	Station Name	Area sq.mi.	Elev ft	Yrs. Rec.	Mean Annual Flood On Basin	Mean Annual Flood + or -	Mn. Annual Flood Per sqmi	Mn. Annual Flood + or -	Sample Std.Dev	Pop. Std.Dev. Not over (95%conf)	F	F.05	Pooled with Sta.Nos.	Pooled Mean On Basin	Pooled Mean Per sqmi	Pooled Std.Dev. On Basin	Pooled Std.Dev. Per sqmi
35	Five Mile Cr nr Wh Sul Spgs	6.0	5380	9	10.78	3.69	1.80	.62	5.95	9.01							
36	Newland Cr nr Wh Sul Spgs	6.7	5590	17	19.70	6.40	2.92	.95	15.11	19.81	19.21	2.84	Cannot Pool Stations				
37	Sheep Creek nr Neihart	5.3	6600	9	72.44	24.01	13.67	4.53	38.73	58.63							
38	Nugget Creek nr Neihart	1.5	6400	10	9.90	2.70	6.69	1.82	4.65	6.84							
39	Smith Cr Trib nr Eden	1.6	3420	9	159.12	49.47	4.69	1.46	4.72	7.15							
40	Goodman Coulee nr Eden	21.8	3370	10	109.08	72.38	5.04	3.32	124.86	183.48							
42	Muddy Cr Trib nr Power	3.2	3710	6	207.50	181.99	65.87	57.78	221.24	389.88							
43	Sun River Trib nr Gt Falls	21.1	3330	13	114.01	68.26	5.40	3.24	138.12	190.57	3.31	2.30	Cannot Pool Stations				
54	Bruce Coulee Trib,Choteau	1.7	3940	6	120.50	73.55	70.88	43.26	89.40	157.55							
55	Kinley Coulee nr Dutton	9.7	3560	5	491.00	854.44	50.78	88.36	896.15	17375.							
56	Kinley Coulee Trib nr Dutton	2.6	3610	6	98.83	149.16	37.30	56.29	181.32	319.74							
44	Mid.Fk.Dry Fk.Marias,Dupuyer	20.2	4120	9	567.44	856.01	28.09	42.38	1380.66	2090.34			45,46	529.44	26.21	1014.24	50.21
45	Heines Coulee Trib nr Valier	.6	3860	9	11.89	12.33	19.81	20.55	19.88	30.10	.11	3.40	44,46	15.73	26.21	30.13	50.21
46	Lone Man Coulee near Valier	14.1	3780	9	433.33	423.91	30.73	30.06	683.72	1035.20			44,45	369.56	26.21	707.96	50.21
47	Marias R. Trib #3 nr Chester	.3	2900	7	10.00	7.12	31.25	22.25	9.70	16.00			47 - 53	9.54	29.80	16.34	51.07
48	Cottonwood Cr Trib, Chester	2.3	3100	6	45.50	33.04	19.96	14.49	40.16	70.78			47 - 53	67.94	29.80	116.44	51.07
49	Cottonwood Trib #2, Chester	24.6	2950	6	80.00	69.36	3.25	2.82	84.32	148.60			47 - 53	733.08	29.80	1256.32	51.07
50	Dead Indian Coulee,Ft.Benton	2.7	3250	5	38.00	46.28	13.92	16.95	48.54	94.11	.76	2.30	47 - 53	81.35	29.80	139.42	51.07
51	Dry Fork Coulee Trib nr Loma	.8	2580	10	42.90	43.16	51.07	51.38	74.46	109.42			47 - 53	25.03	29.80	42.90	51.07
52	Marias River Trib nr Loma	1.6	2590	13	42.15	40.52	26.02	25.02	81.99	113.13			47 - 53	48.28	29.80	82.73	51.07
53	Marias R. Trib #2 at Loma	.2	2590	11	10.27	7.05	41.09	28.21	12.91	18.51			47 - 53	7.45	29.80	12.77	51.07
59	Casino Cr Trib nr Lewistown	3.5	4200	9	23.56	14.13	6.67	4.00	22.79	34.50			60,76,77	85.21	24.14	181.23	51.34
60	Cottonwood Creek nr Moore	47.9	4300	11	1309.70	1799.80	27.34	37.58	3294.40	4723.10	.49	2.92	59,76,77	1156.30	24.14	2459.19	51.34
76	Alkali Creek near Heath	3.8	4060	8	136.00	169.93	36.17	45.19	253.63	398.68			59,60,77	90.77	24.14	193.04	51.34
77	S.Fk.McDonald Cr Trib,Gs Rge	.5	3700	6	14.50	10.85	28.43	21.27	13.18	23.24			59,60,76	12.51	24.14	26.18	51.34
61	Missouri R. Trib, Landusky	3.4	2280	6	33.67	33.76	9.93	9.96	41.04	72.32	2.56	4.96	62	68.88	20.32	81.50	24.04
62	Duval Cr near Landusky	3.3	2900	30	101.67	80.11	30.72	24.20	97.39	171.62			61	67.26	20.32	79.57	24.04
63	Antelope Cr Trib, Harlowton	.5	5400	10	3.30	2.44	7.02	5.20	4.22	6.20	7.58	4.35	Cannot Pool Stations				
64	Antelope Trib nr mouth,Harl'ton	1.9	5000	12	76.25	36.33	39.71	18.92	70.07	98.39							
65	Antelope Cr Trib #2,Harl'ton	21.2	4250	10	564.70	574.86	26.64	27.12	991.74	1457.30	.09	4.45	66	666.00	31.42	1450.	68.45
66	Antelope Creek at Harlowton	88.7	4150	9	3258.20	4926.60	36.73	55.54	7946.10	12031.			65	2785.00	31.42	6060.	68.45

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

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					On Basin	+ or -	Per sqmi	+ or -						On Basin	Per sqmi	On Basin	Per sqmi
67	Currant Cr nr Roundup	200.	3250	10	315.90	300.60	1.44	1.37	518.59	762.05							
68	S.Willow Cr Trib, Roundup	1.4	3450	7	204.29	148.37	148.03	107.51	202.37	333.34							
69	Musselshell Trib,Musselshell	10.8	3070	5	65.20	76.04	6.04	7.04	79.76	154.64	5.99	2.71	Cannot Pool Stations				
70	Home Creek near Melstone	31.2	2860	5	84.40	98.32	2.70	3.15	103.12	199.95							
71	Butts Coulee near Melstone	6.0	2810	6	111.67	84.39	18.74	14.16	102.59	180.78							
72	S.Fk. Bear Creek near Roy	39.6	3250	7	460.71	400.59	11.63	10.12	545.47	900.00							
73	S.Fk. Bear Cr. Trib nr Roy	5.4	3300	7	43.00	21.31	7.96	3.94	29.01	47.87							
74	Box Elder Trib nr Winnett	16.2	2740	14	158.14	50.69	9.76	3.13	107.10	145.52							
78	McDonald Cr at Winnett	421.	2930	30	401.28	103.35	.95	.24	333.18	403.55	9.05	1.86	Cannot Pool Stations				
79	Gorman Coulee nr Cat Creek	2.3	2740	12	116.08	67.35	50.04	29.03	129.90	182.42							
80	Gorman Coulee Trib,CatCreek	.8	2760	13	68.31	35.20	84.33	43.46	71.23	98.28							
81	Cat Creek near Cat Creek	36.5	2650	11	157.36	121.69	4.31	3.33	222.75	319.35							
82	Second Cr. Trib nr Jordan	36.5	2750	12	62.42	62.34	83.22	83.12	120.25	168.87			82-85	2068.46	56.67	5433.39	148.86
83	Second Cr. Trib#2 nr Jordan	1.9	2750	11	95.54	121.06	50.29	63.72	221.59	317.69	.81	2.76	82-85	106.67	56.67	282.83	148.86
84	Second Cr. Trib#3 nr Jordan	.6	2780	11	53.64	73.44	89.39	122.40	134.42	192.71			82-85	34.00	56.67	89.32	148.86
85	Little Dry Cr nr Van Norman	1224.	2350	11	1686.40	771.35	1.38	.63	1411.8	2024.2			82-85	69364.08	56.67	182204	148.86
86	Livermore Creek near Babb	25.0	4730	6	1175.50	1529.00	47.02	61.16	1858.60	3275.40			87,88	882.75	35.31	1277.00	51.08
87	Middle Fk Milk R. near Babb	14.0	4810	3	231.67	480.84	16.55	34.35	285.22	878.13	.33	3.81	86,88	494.34	35.31	715.12	51.08
88	Dry Fk Milk River near Babb	17.4	4750	7	579.57	488.29	33.31	28.06	664.89	1097.0			86,87	614.39	35.31	888.79	51.08
91	Sage Cr Trib nr Hingham	1.1	3000	9	46.57	59.38	43.12	54.99	95.78	145.02			91-96	10.09	9.35	37.42	34.65
92	S.Fk. Spring Coulee nr Havre	6.5	2770	9	43.23	36.40	6.68	5.62	58.71	88.88			91-96	60.49	9.35	224.18	34.65
93	Spring Coulee near Havre	17.8	2670	10	92.90	69.81	5.22	3.92	120.43	176.97	2.30	4.01	91-96	166.43	9.35	616.77	34.65
94	Big Sandy Cr. nr Assiniboine	1805.	2510	21	857.24	491.06	.47	.27	1304.5	1653.9			91-96	16876.75	9.35	62543.25	34.65
95	Bullhook Creek near Havre	39.6	2610	9	102.78	59.68	2.60	1.51	96.26	145.74			91-96	370.26	9.35	1372.14	34.65
96	Milk River Trib nr Lohman	.2	2450	9	1.64	1.79	10.28	11.20	2.89	4.37			91-96	1.49	9.35	5.54	34.65
97	Black Coulee near Malta	6.6	2450	10	95.00	41.89	14.31	6.31	72.27	106.20							
98	Alkali Creek near Malta	162.	2270	7	428.43	233.49	2.64	1.44	317.94	524.59	3.38	2.90	Cannot Pool Stations				
99	Disjardin Coulee nr Malta	3.4	2290	13	90.15	51.12	26.36	14.95	103.44	142.72							
100	S.Fk. Taylor Cr nr Malta	5.1	2290	11	35.45	18.58	6.98	3.66	34.02	48.77							
101	Unger Cr nr Vandalia	11.1	2220	11	125.73	99.37	11.32	8.95	181.88	260.77			102,109	33.25	7.50	1380.84	12.44
102	Mooney Coulee nr Tampico	12.8	2220	7	113.14	107.99	8.84	8.44	147.05	242.63	.99	3.23	101,109	96.00	7.50	159.23	12.44
109	Wolf Cr nr Wolf Point	251.	2010	20	1238.20	981.33	4.93	3.91	2538.26	3041.39			101,102	1882.50	7.50	3122.44	12.44
104	E.Fk. Sand Cr near Vida	8.5	2200	6	382.17	360.81	44.91	42.40	438.61	772.95			118,119	371.53	67.16	925.97	108.81
118	Cow Cr. Trib near Vida	1.7	2390	6	172.83	240.24	101.07	140.49	292.05	514.67	.43	3.74	104,119	114.84	67.16	186.06	108.81
119	Wolf Cr. Trib near Vida	.9	2010	5	48.40	60.54	53.19	66.53	63.50	123.12			104,118	61.12	67.16	99.02	108.81

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Sta. No.	Station Name	Area sq.mi	Elev ft	Yrs. Rec.	Mean Annual Flood		Mn.Annual Flood		Sample Std.Dev	Pop. Std.Dev. Not over (95%conf)	F	$F_{.05}$	Pooled with Sta.Nos.	Pooled Mean		Pooled Std.Dev.	
					On Basin	+ or -	Per sqmi	+ or -						On Basin	Per sqmi	On Basin	Per sqmi
110	E.Fk. Duck Cr nr Brockway	12.4	2660	14	190.93	88.31	15.40	7.12	186.58	253.51							
111	Duck Creek near Brockway	54.0	2580	12	328.42	184.29	6.08	3.41	355.46	499.17							
112	Redwater R. near Brockway	216.	2550	11	682.72	273.76	3.16	1.27	501.08	718.40							
113	Tusler Cr. nr Brockway	90.2	2550	11	176.09	67.78	1.95	.75	124.06	177.86	2.46	2.13	Cannot Pool Stations		-		
114	Tusler Cr. Trib nr Brockway	3.2	2590	7	230.00	446.89	72.56	140.96	608.52	1004.03							
115	Redwater R. Trib, Brockway	.3	2500	13	35.85	32.25	123.61	111.21	65.25	90.03							
116	S.Fk. Dry Ash Cr nr Circle	5.7	2670	13	37.31	15.09	6.50	2.63	30.53	42.12							
117	McCune Creek near Circle	29.9	2500	13	199.31	132.79	6.66	4.44	268.68	370.70							
120	Missouri Trib#2 nr Brockton	1.6	1960	7	115.14	87.01	71.96	54.38	118.48	195.48			120-129	177.58	110.99	574.62	359.14
126	Big Muddy Trib nr Culbertson	7.4	1940	6	196.00	218.21	26.56	29.57	265.67	467.47			120-129	819.11	110.99	2650.45	359.14
127	Missouri Trib#3 nr Culbertson	1.3	1950	5	545.80	1080.38	423.10	837.50	1133.11	2197.01	1.18	3.07	120-129	143.18	110.99	463.29	359.14
128	Missouri Trib#4 nr Bainville	11.6	2000	6	618.67	451.81	53.33	38.95	549.23	967.89			120-129	1287.48	110.99	4166.02	359.14
129	Missouri Trib#5 nr Culbertson	3.7	1970	6	141.33	147.01	38.51	40.06	178.71	314.93			120-129	407.33	110.99	1318.04	359.14
121	Big Muddy Cr nr Plentywood	850.	1980	18	1893.22	924.82	2.23	1.09	2255.00	2927.74							
122	Box Elder Cr nr Plentywood	9.4	2200	13	116.85	49.67	12.43	5.28	100.51	138.67							
123	Box Elder cr at Damsite	19.9	2120	10	1163.50	1124.09	58.47	56.49	1939.27	2849.68	4.00	2.53	Cannot Pool Stations				
124	Spring Cr nr Plentywood	7.0	2260	14	46.07	28.74	6.53	4.08	60.71	82.49							
125	Spring Cr, Hwy 16, Plentyw'd	19.9	2040	13	205.00	125.33	12.13	7.42	252.57	349.85							
130	Yellowstone Trib, Greycliff	2.7	3860	9	11.78	10.67	4.33	3.92	17.21	26.05			130-134	15.97	5.87	27.64	10.16
131	Bridger Cr near Greycliff	61.5	4080	9	440.44	549.75	7.16	8.94	886.70	1342.48			130-134	351.00	5.87	624.84	10.16
132	Work Creek nr Reed Point	32.5	3820	10	166.80	139.83	5.13	4.30	241.24	354.49	.45	2.61	130-134	190.76	5.87	330.20	10.16
133	Hump Creek nr Reed Point	7.6	3780	8	72.75	70.54	9.56	9.27	105.28	165.50			130-134	44.67	5.87	77.32	10.16
134	Berry Creek near Columbus	23.5	3700	10	96.98	118.09	4.13	5.02	203.73	299.38			130-134	137.94	5.87	238.76	10.16
135	Allen Creek near Park City	7.2	3470	8	285.75	355.67	38.85	49.60	530.86	834.46							
136	Wets Creek near Billings	8.2	3550	14	143.21	66.82	17.59	8.21	141.81	191.82							
137	W.Buckeye Cr nr Billings	1.5	3500	14	101.00	35.14	65.58	22.82	74.23	100.86	7.89	2.50	Cannot Pool Stations				
138	Pryor Creek near Billings	435.	3310	42	758.43	156.06	1.74	.35	600.93	702.51							
139	Crooked Cr. Trib, Shepherd	7.2	3400	7	1165.29	1317.43	161.61	182.72	1793.92	2959.87							
140	Yellowstone Trib#2,P-Pillar	.7	2850	4	0	0	0	0	0	0							
142	Unknown Cr nr Big Horn	14.6	2690	7	392.00	220.75	26.85	15.12	300.60	495.97							
143	Buckingham Coulee nr Myers	2.6	2820	7	86.71	105.11	32.97	39.96	143.12	236.15							
144	M.Fk.Froze-to-Death Trib	1.4	2990	7	149.28	121.65	109.77	89.45	165.65	273.31	4.84	2.29	Cannot Pool Stations				
145	Yellowstone Trib#3,Forsyth	4.4	2550	7	342.00	280.08	78.08	63.94	381.38	629.25							
146	L.Porcupine Cr. nr Forsyth	614.	2480	11	1997.27	535.29	3.25	.87	979.78	1404.71							
151	Rosebud Creek nr Forsyth	1260.	2540	16	372.00	57.41	.30	4.56	131.00	173.55							

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

Sta. No.	Station Name	Area sq.mi	Elev ft	Yrs. Rec.	Mean Annual Flood		Mn. Annual Flood		Sample Std.Dev	Pop. Std.Dev. Not over (95%conf)	F	$F_{.05}$	Pooled with Sta.Nos.	Pooled Mean		Pooled Std.Dev.	
					On Basin	+ or -	Per sqmi	+ or -						On Basin	Per sqmi	On Basin	Per sqmi
148	Rosebud Cr trib nr Burly	1.1	3310	6	4.67	3.28	4.09	2.87	3.98	7.02							
150	Whitedirt Cr nr Lame Deer	1.6	3290	10	17.90	9.15	11.33	5.79	15.79	23.20	17.68	3.49	Cannot Pool Stations				
155	Spring Creek nr Ashland	1.5	2980	7	105.86	44.49	71.52	30.06	60.58	99.96							
152	Snell Cr nr Hathaway	10.5	2550	6	170.17	129.76	16.21	12.36	157.74	277.98							
161	N.Fk.Sunday Cr Trib,RockSpgs	1.2	2970	6	12.00	12.49	10.08	10.49	15.18	26.75							
162	DryHouse Cr nr Angela	35.6	2760	6	447.50	453.79	12.57	12.75	551.64	972.14	7.37	2.51	Cannot Pool Stations				
164	Deep Creek near Kinsey	11.1	2320	7	1091.10	591.65	98.30	53.30	805.64	1329.30							
163	N.Fk Sunday Cr Trib#2,Angela	.3	2680	7	82.57	43.52	242.86	128.00	59.26	97.98							
167	Myers Creek near Locate	9.6	2520	7	385.00	334.37	40.19	34.90	455.30	751.23							
147	Rosebud Creek near Kirby	34.2	4180	9	155.44	107.58	4.54	3.14	173.52	261.72							
153	Spring Creek near Decker	36.3	3500	11	193.64	148.41	5.33	4.09	271.65	389.46	5.92	3.37	Cannot Pool Stations				
154	Leaf Rock Creek near Kirby	6.0	3950	9	115.44	58.70	19.11	9.72	94.69	143.36							
159	Basin Cr Trib near Volberg	.1	2900	14	52.57	48.07	375.51	343.36	101.56	137.99							
160	Basin Creek near Volberg	10.9	2850	14	378.79	171.75	34.48	15.76	362.86	493.01	3.38	2.50	Cannot Pool Stations				
166	Sand Creek near Broadus	10.6	3090	14	49.48	34.04	4.66	3.21	71.93	97.73							
168	O'Fallon Creek near Ismay	669.	2590	7	4640.30	6854.30	6.94	9.78	8916.70	14712.							
169	O'Fallon Cr Trib nr Ismay	.2	2750	7	50.43	9.40	296.64	55.32	12.80	21.13							
170	Deep Creek near Baker	1.6	3080	7	118.71	38.95	76.59	25.13	53.04	87.51	23.35	2.50	Cannot Pool Stations				
171	Pennel Creek near Baker	1.0	3080	7	132.86	86.59	132.86	86.59	117.91	194.55							
183	N.Fk.Coal Bank Cr nrMillIron	15.0	3040	5	133.00	77.28	8.87	5.15	81.06	157.16							
184	Soda Cr. Trib. nr Webster	2.2	3100	7	25.57	26.62	11.52	11.99	36.25	59.82							
172	Yellowstone Trib#4, Fallon	.7	2250	7	122.57	92.86	182.94	138.59	126.44	208.62			172-185	32.37	48.31	97.06	144.86
173	Yellowstone Trib#5 nr Marsh	.9	2300	7	24.71	33.53	28.41	38.54	45.65	75.32			172-185	42.03	48.31	126.03	144.86
174	Krug Cr Trib nr Wibaux	1.7	2720	7	20.14	20.76	11.58	11.93	28.27	46.64			172-185	84.06	48.31	252.06	144.86
175	Griffith Cr nr Glendive	15.5	2220	9	1697.70	2999.90	109.53	193.54	4838.50	7325.60	1.87	2.28	172-185	748.81	48.31	2245.33	144.86
176	Linden Creek at Intake	5.0	2800	11	8.54	4.50	1.70	.90	8.24	11.81			172-185	242.03	48.31	725.75	144.86
179	First Hay Cr near Sidney	30.0	2170	6	63.33	43.97	2.11	1.46	53.45	94.19			172-185	1449.30	48.31	4345.80	144.86
185	Spring Creek nr Wibaux	3.9	2770	13	95.77	54.97	24.68	14.17	111.23	153.46			172-185	187.44	48.31	562.06	144.86
180	North Creek near Alzada	.7	3480	15	349.07	146.25	513.33	215.08	321.65	431.20							
181	Wolf Creek near Hammond	9.1	3590	14	422.29	166.17	46.46	18.28	351.07	477.00	12.99	3.26	Cannot Pool Stations				
182	Willow Creek near Alzada	123.0	3400	11	694.82	339.53	5.65	2.76	621.46	891.00							
186	Fortine Creek near Trego	112.0	3340	18	872.33	166.72	7.79	1.49	406.50	527.78							
189	Deep Creek near Fortine	17.9	3000	10	156.80	38.48	8.76	2.15	66.38	97.54	7.84	3.34	Cannot Pool Stations				
221	Spring Creek near Stryker	3.9	3260	3	10.00	3.37	2.59	.87	2.00	6.16							
222	Rock Creek near Olney	6.2	3240	8	16.62	5.56	2.69	.90	8.30	13.04							

TESTS OF ANNUAL PEAK DISCHARGE DATA TO DETERMINE HYDROLOGICALLY HOMOGENEOUS AREAS

Sta. No.	Station Name	Area sq.mi	Elev ft	Yrs. Rec.	Mean Annual Flood On Basin	Mean Annual Flood + or -	Mn. Annual Flood Per sqmi	Mn. Annual Flood + or -	Sample Std.Dev	Pop. Std.Dev. Not over (95%conf)	F	$F_{.05}$	Pooled with Sta.Nos.	Pooled Mean On Basin	Pooled Mean Per sqmi	Pooled Std.Dev. On Basin	Pooled Std.Dev. Per sqmi
188	Kootenai R.Trib nr Rexford	1.1	2280	10	6.60	1.94	5.95	1.74	3.34	4.91	5.95	4.41	Cannot Pool Stations				
189	Gold Creek near Rexford	6.0	2260	10	64.50	18.72	10.68	3.10	32.30	47.46							
191	L. Jackson Creek near Libby	2.6	2180	4	8.50	5.48	3.27	2.11	4.65	10.55							
191	Peoples Creek near Libby	2.6	2200	6	5.50	4.73	2.08	1.78	5.75	10.14	7.01	3.63	Cannot Pool Stations				
194	Shaughnessy Cr. nr Libby	1.1	2820	9	20.00	8.65	18.02	7.79	13.95	21.13							
195	Whitetail Creek near Yaak	2.6	2930	9	27.11	8.04	10.39	3.08	12.98	19.64							
197	Fourth-of-July Cr nr Yaak	7.7	2650	9	174.56	33.97	22.67	4.41	54.79	82.95	12.06	4.49	Cannot Pool Stations				
196	Cyclone Creek near Yaak	5.7	2790	9	140.11	27.10	24.76	4.79	43.70	66.17							
199	Clark Fork Trib nr Drummond	4.6	4080	11	54.72	24.68	11.87	5.35	45.17	64.75	6.66	3.52	Cannot Pool Stations				
200	Morris Creek near Drummond	12.6	4170	9	9.33	2.50	.74	.20	4.03	6.10							
201	Edwards Gulch near Drummond	4.7	4000	2	5.00	18.94	1.07	4.04	4.24	33.75							
202	West Twin Cr nr Bonner	7.5	3410	10	105.50	26.57	14.12	3.56	45.33	67.35							
203	Marshall Cr nr Missoula	5.5	3310	10	16.40	7.47	3.00	1.36	12.89	18.94	90.54	4.41	Cannot Pool Stations				
211	Hayes Creek nr Missoula	4.2	3300	9	15.22	11.16	3.66	2.68	18.00	27.25							
204	Burke Gulch near Darby	6.3	4100	11	7.27	1.92	1.16	.31	3.52	5.05							
205	Camas Creek nr Hamilton	6.0	4000	11	155.18	35.19	25.82	5.85	64.40	92.34							
206	Willow Creek nr Corvallis	22.4	4130	17	104.24	11.78	4.65	.53	27.83	36.48	77.95	2.32	Cannot Pool Stations				
208	Kootenai Cr nr Stevensville	28.9	3780	17	814.41	112.58	28.18	3.90	265.84	348.47							
209	Burnt Fork Cr, Stevensville	74.0	4270	35	361.89	54.79	4.89	.74	191.47	228.38							
210	Eightmile Cr nr Florence	20.6	3800	11	50.09	13.02	2.43	.63	23.83	34.16							
212	Nigger Gulch nr Alberton	8.0	3000	10	39.40	28.12	4.91	3.51	48.52	71.29							
214	Thompson Cr nr Superior	12.2	2710	8	73.37	35.64	6.01	2.92	53.20	83.63	4.34	4.16	Cannot Pool Stations				
215	E.Fk. Timber Cr nr Haugan	2.7	3350	8	34.75	11.23	12.78	4.13	16.76	26.35							
217	N.Fk.LittleJoe Cr,StRegis	14.7	2850	9	152.00	34.55	10.34	2.35	55.72	84.37							
219	Moccasin Cr nr W.Glacier	2.0	3300	6	90.00	26.68	45.68	13.54	32.43	57.15	.10	4.75	220	85.00	43.15	49.80	25.28
220	N.Fk.Flathead Trib, W.G'cier	.1	3250	8	4.12	2.10	41.25	21.02	3.14	4.93			219	4.32	43.15	2.53	25.28
223	Dayton Creek near Proctor	20.9	3350	10	50.30	21.40	2.41	1.02	36.91	54.24							
224	Teepee Creek near Polson	2.6	2910	7	9.28	4.42	3.64	1.73	6.02	9.93							
225	Hell Roaring Cr nr Polson	6.4	3150	26	37.91	9.40	5.92	1.47	28.06	34.57	3.13	2.54	Cannot Pool Stations				
226	Mill Creek near Niarada	28.0	3000	10	106.40	39.91	3.80	1.42	68.85	101.17							
228	Garden Cr. near Hot Springs	8.3	3300	10	29.50	16.23	8.97	4.93	28.01	41.16							

APPENDIX J

EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS:

Grasshopper Creek
Pryor Creek
Burnt Fork Creek
McDonald Creek

TABLE J-1 EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS AT GRASSHOPPER CREEK (348 square miles, 33 years record)

Year	Discharge cfs	First Half Data Order	First Half Data t_p	Second Half Data Order	Second Half Data t_p	Total Record Data Order	Total Record Data t_p
1921	516	5	3.40			14	2.43
1922	543	4	4.30			11	3.09
1923	283	10	1.70			24	1.41
1924	120	15	1.13			32	1.06
1925	557	3	5.70			10	3.40
1926	197	12	1.42			28	1.21
1927	355	6	2.80			19	1.79
1928	327	7	2.40			21	1.62
1929	172	13	1.31			30	1.13
1931	85	16	1.06			33	1.03
1932	322	9	1.88			23	1.47
1946	160	14	1.21			31	1.09
1947	640	2	8.50			6	5.66
1948	719	1	17.00			5	6.80
1949	324	8	2.10			22	1.55
1950	252	11	1.55			27	1.25
1951	559			7	2.57	9	3.78
1952	257			15	1.20	25	1.36
1953	719			4	4.50	5	6.80
1955	328			14	1.29	20	1.70
1956	1870			1	18.00	1	34.00
1957	433			13	1.38	18	1.89
1958	579			6	3.00	8	4.25
1960	539			9	2.00	13	2.62
1961	252			16	1.12	27	1.26
1962	450			11	1.64	16	2.13
1963	465			10	1.80	15	2.27
1964	539			9	2.00	13	2.62
1965	635			5	3.60	7	4.85
1966	180			16	1.06	29	1.17
1967	730			3	6.00	3	11.33
1968	435			12	1.50	17	2.00
1969	1140			2	9.00	2	17.00

	Mean Annual Peak, cfs	Standard Deviation, cfs
1st 16 years record	348.3	192.9
2nd 17 years record	594.7	397.7
total 33 year record	475.2	334.9

Gumbel Method:

	$Q_{1.5\ yr}$	$Q_{200\ yr}$
1st 16 years record	234.1 cfs	1244.5 cfs
total 33 year record	286.3	1895.2

Log-Normal Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{5\ yr}$	$Q_{100\ yr}$
1st 16 years record	60.9 cfs	330.9 cfs	502.6 cfs	869.1 cfs
total 33 year record	126.9	391.5	669.4	1690.9

Log-Pearson Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{2.5\ yr}$	$Q_{16\ yr}$
1st 16 years record	107.1 cfs	296.8 cfs	408.2 cfs	817.1 cfs
total 33 year record	126.3 cfs	364.6	510.2	1052.0

TABLE J-2 EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS AT PRYOR CREEK (438 square miles, 44 years record)

Year	Discharge	First Half Data		Second Half Data		Total Record Data	
	cfs	Order	t_p	Order	t_p	Order	t_p
1912	930	6	3.83			13	3.46
1913	1130	4	5.75			10	4.50
1914	595	14	1.64			26	1.73
1915	645	10	2.30			22	2.05
1916	333	20	1.15			36	1.25
1917	750	7	3.28			19	2.37
1918	480	17	1.35			31	1.45
1919	344	19	1.21			35	1.29
1920	740	8	2.88			20	2.25
1921	635	11	2.09			23	1.96
1922	400	18	1.28			34	1.32
1923	590	15	1.53			27	1.67
1924	705	9	2.55			21	2.14
1938	1230	2	11.50			8	5.62
1939	332	21	1.09			37	1.22
1940	208	22	1.05			42	1.07
1941	607	13	1.77			25	1.80
1942	1500	1	23.00			4	11.25
1943	1000	5	4.60			12	3.75
1944	1150	3	7.67			9	5.00
1945	625	12	1.92			24	1.88
1946	489	16	1.44			30	1.50
1947	890			8	2.88	14	3.21
1948	464			15	1.53	32	1.41
1949	133			22	1.05	44	1.02
1950	230			20	1.15	41	1.10
1951	761			12	1.92	18	2.50
1952	424			16	1.44	33	1.36
1953	145			21	1.09	43	1.05
1955	286			18	1.28	39	1.15
1956	800			11	2.09	17	2.65
1957	825			10	2.30	16	2.81
1958	262			19	1.21	40	1.13
1959	508			14	1.64	29	1.55
1960	1700			2	11.50	2	22.50
1961	288			17	1.35	38	1.18
1962	840			9	2.55	15	3.00
1963	1330			5	4.60	6	7.50
1964	3720			1	23.00	1	45.00
1965	1040			7	3.28	11	4.09
1966	1440			4	5.75	5	9.00
1967	520			13	1.77	28	1.61
1968	1270			6	3.83	7	6.42
1969	1600			3	7.67	3	15.00

	Mean Annual Peak, cfs	Standard Deviation, cfs
1st 22 years record	700.8 cfs	332.5
2nd 22 years record	885.3	793.1
total 44 year record	793.0	608.5

TABLE J-2(Continued)

EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS AT PRYOR CREEK (438 square miles, 44 years record)

Gumbel Method:	$Q_{1.5\ yr}$	$Q_{200\ yr}$
1st 22 years record	508.9 cfs	2175.2 cfs
total 44 year record	454.4 cfs	3306.9 cfs

Log-Normal Method:	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{5\ yr}$	$Q_{100\ yr}$
1st 22 years record	234.3 cfs	657.6 cfs	956.8 cfs	1665.1 cfs
total 44 year record	221.0	622.6	1097.3	3099.2

Log-Pearson Method:	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{3.3\ yr}$	$Q_{17\ yr}$
1st 22 years record	223.2 cfs	668.7 cfs	947.0 cfs	2004 cfs
total 44 year record	188.1	652.3	967.5	2262

TABLE J-3 EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS AT BURNT FORK CREEK (74 square miles, 36 years record)

Year	Discharge cfs	First Half Data Order	First Half Data t_p	Second Half Data Order	Second Half Data t_p	Total Record Data Order	Total Record Data t_p
1920	347	9	2.11			17	2.25
1922	620	2	9.50			4	9.00
1923	276	11	1.73			27	1.38
1924	268	12	1.58			28	1.33
1938	641	1	19.00			3	12.00
1939	192	13	1.46			31	1.20
1940	121	17	1.12			35	1.06
1941	119	18	1.06			36	1.03
1942	371	7	2.71			14	2.77
1943	382	5	3.80			11	3.27
1944	183	14	1.36			32	1.16
1945	139	16	1.19			34	1.09
1946	142	15	1.27			33	1.13
1947	414	4	4.75			9	4.00
1948	565	3	6.33			5	7.20
1949	310	10	1.90			23	1.64
1950	379	6	3.17			12	3.00
1951	361	8	2.38			15	2.57
1952	233			18	1.06	30	1.24
1953	351			8	2.38	16	2.40
1954	300			15	1.27	25	1.50
1955	284			16	1.19	26	1.44
1956	414			5	3.80	9	4.00
1957	320			10	1.90	19	2.00
1958	371			7	2.71	14	2.77
1959	310			13	1.46	23	1.64
1960	317			11	1.73	20	1.90
1961	411			6	3.17	10	3.60
1962	303			14	1.36	24	1.57
1963	312			12	1.58	21	1.80
1964	720			2	9.50	2	18.00
1965	530			3	6.33	6	6.00
1966	240			17	1.12	29	1.29
1967	1100			1	19.00	1	36.00
1968	320			10	1.90	19	2.00
1969	450			4	4.75	7	5.14

	Mean Annual Peak, cfs	Standard Deviation, cfs
1st 18 years record	342.9	164.2
2nd 18 years record	404.8	208.2
total 36 year record	374.7	189.3

Gumbel Method:

	$Q_{1.5\ yr}$	$Q_{200\ yr}$
1st 18 years record	246.2 cfs	1099.2 cfs
total 36 year record	268.3	1166.7

Log-Normal Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{5\ yr}$	$Q_{100\ yr}$
1st 18 years record	155.7 cfs	306.8 cfs	448.0 cfs	907.7 cfs
total 36 year record	170.3	339.3	488.3	1046.7

Log-Pearson Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{3.3\ yr}$	$Q_{17\ yr}$
1st 18 years record	111.3 cfs	278.1 cfs	371.8 cfs	694.9 cfs
total 36 year record	146.7	325.1	418.3	720.0

TABLE J-4 EFFECT OF RECORD LENGTH ON PEAK FLOW PREDICTIONS AT McDONALD CREEK (421 square miles, 31 years record)

Year	Discharge	First Half Data		Second Half Data		Total Record Data	
	cfs	Order	t_p	Order	t_p	Order	t_p
1931	4.2	14	1.07			30	1.07
1932	562	3	5.00			7	4.57
1934	351	8	1.88			16	2.00
1935	371	7	2.14			15	2.13
1936	220	11	1.36			21	1.52
1937	401	6	2.50			13	2.46
1938	328	9	1.67			17	1.88
1939	270	10	1.50			18	1.78
1940	75	13	1.15			27	1.19
1941	482	5	3.00			11	2.91
1942	900	1	15.00			2	16.00
1943	549	4	3.75			8	4.00
1944	853	2	7.50			4	8.00
1945	180	12	1.25			24	1.33
1953	424			7	2.57	12	2.66
1954	47			16	1.13	29	1.10
1955	241			10	1.80	20	1.60
1956	88			14	1.29	26	1.23
1957	67			15	1.20	28	1.14
1958	150			13	1.38	25	1.28
1959	400			8	2.25	14	2.29
1960	200			12	1.50	23	1.39
1961	0.1			17	1.06	31	1.03
1962	485			6	3.00	10	3.55
1963	250			9	2.00	19	1.68
1964	1440			1	18.00	1	32.00
1965	800			4	4.50	6	5.33
1966	200			12	1.50	23	1.39
1967	890			2	9.00	3	10.67
1968	810			3	6.00	5	6.40
1969	500			5	3.60	9	3.56

	Mean Annual Peak, cfs	Standard Deviation, cfs
1st 14 years record	396.1	267.8
2nd 17 years record	411.3	382.8
total 31 year record	404.5	327.8

Gumbel Method:

	$Q_{1.5\ yr}$	$Q_{200\ yr}$
1st 14 years record	233.3 cfs	1649.7 cfs
total 31 year record	219.2 cfs	1801.5 cfs

Log-Normal Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{5\ yr}$	$Q_{100\ yr}$
1st 14 years record	- 2.9 cfs	372.0 cfs	610.3 cfs	1119.2 cfs
total 31 year record	-15.1	348.8	640.5	1446.9

Log-Pearson Method:

	$Q_{1.05\ yr}$	$Q_{2.0\ yr}$	$Q_{3.2\ yr}$	$Q_{16\ yr}$
1st 14 years record	28.5 cfs	260.4 cfs	525.3 cfs	2381.0 cfs
total 31 year record	10.9	215.7	554.7	4240.0